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Flue Gas Desulfurization Information System (FGDIS) Data Base User's Manual

PEI Associates, Inc., Cincinnati, OH

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FLUE GAS DESULFURIZATION INFORMATION SYSTEM (FGDIS) DATA BASE USER'S MANUAL

by

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16. ABSTRACT The document is a user's manual and reference book/primer for Flue Gas Desulfurization Information System (FGDIS) users and recipients of the quarterly Utility FGD Survey. Part I, interactive computer procedures for the FGDIS, addresses the use of and terminology related to the use of the computerized data base. Part II, FGDIS terminology, addresses FGD technology as it relates to this computerized data base. The primary thrust of Part II concerns equipment/component classifications: major equipment items and construction materials are broken down into primary, secondary, and tertiary categories referred to as generic type, specific type, and trade/common name (or common design). This is supported by an appendix that describes the use of problem/solution codes. A glossary, defining common scrubber- and boiler-related FGD terms, includes definitions of data field titles in FGDIS that may be unclear to new FGDIS users or individuals somewhat detached from the system.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Pollution	Pollution Control	13B
Flue Gases	Stationary Sources	21B
Desulfurization	Flue Gas Desulfurization	07A, 07D
Information Systems	Information Systems	09B, 05B
Data	FGDIS	14G
Scrubbers		07I, 13I
Boilers		13A

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ABSTRACT

The Flue Gas Desulfurization Information System (FGDIS) Data Base User's Manual provides FGDIS users a two-part reference document. The first part covers the features of the computerized data base management system (DBMS) and how the user may use these features to extract specific information from the FGDIS. The second part discusses FGDIS terminology as it relates to the existing utility flue gas desulfurization technology today.

The FGDIS is available to individuals interested in acquiring specific information on the status of utility FGD technology not readily available through the quarterly Utility FGD Survey Report. The Utility FGD Survey Report, which is a major product of the FGDIS, is available through the National Technical Information Service, Springfield, Virginia (703/487-4650). This report includes a significant portion of the information collected within the FGDIS; however, important data such as dependability, cost, specific design, etc. are not included and can only be obtained through access to the FGDIS.

CONTENTS

Page

Figures ix
Tables xi
Introduction xii

I. INTERACTIVE COMPUTER PROCEDURES FOR THE FGDIS

1. General Information 1

2. Data Base Structure 2

    2.1 Structure diagram 2
    2.2 Field listing ("DESCRIBE" output) 2

3. Data Base Execution 25

    3.1 NCC access 25
        3.1.1 Computer log-on 26
        3.1.2 Computer log-off 38

    3.2 SYSTEM 2000 execution/termination 39
        3.2.1 Output interrupt 40

    3.3 Immediate access features 40
        3.3.1 DESCRIBE command 41
        3.3.2 TALLY command 41
        3.3.3 PRINT command 43
        3.3.4 Format statement 46
        3.3.5 System functions 49
        3.3.6 In-line functions 51
        3.3.7 Ordering statements 52
        3.3.8 LIST command 53
        3.3.9 BY clause 61
        3.3.10 WHERE clause 66
        3.3.11 Unary operators: EXISTS, FAILS 70
        3.3.12 Binary operators: EQ, NE, LT, LE, GT, GE, 71
        3.3.13 Ternary operators: EQ, NE, SPANS 71
        3.3.14 Boolean operators: AND, OR, NOT 72
        3.3.15 HAS operator 75
        3.3.16 DITTO operator 78
        3.3.17 SAME operator 79

    3.4 Report writer feature 79

CONTENTS (continued)

Page

4. Output Control 81

    4.1 NCC bin assignments 81
    4.2 Directing output to NCC bins for mailing 81

II. FGDIS TERMINOLOGY

5. Basic Scrubber/Absorber Types 85

    5.1 Generic and specific classifications 85
        5.1.1 Scrubber/absorber classification descriptions 85

6. Basic Mist Eliminator Types 98

    6.1 Generic and specific classifications 98
        6.1.1 Precollector mist eliminator classification descriptions 100
        6.1.2 Primary collector mist eliminator classification descriptions 100

7. Basic Reheater Types 107

    7.1 Generic and specific classifications 107
        7.1.1 Reheater classification descriptions 107

8. Basic Solids Dewatering Device Types 118

    8.1 Generic and specific classifications 118
        8.1.1 Solids dewatering classification descriptions 118

9. Basic Sludge Processing Types 130

    9.1 Generic and specific classifications 130
        9.1.1 Sludge processing classification descriptions 130

10. Sludge Disposal Site Types 138

    10.1 Generic and specific classifications 138
        10.1.1 Sludge disposal site classification descriptions 138

CONTENTS (continued)

Page

11. Basic Reagent Preparation Equipment Types 146

    11.1 Generic and specific classifications 146
        11.1.1 Reagent preparation equipment descriptions 146

12. Basic Pump Types 153

    12.1 Generic and specific classifications 153
        12.1.1 Pump classification descriptions 153

13. Basic Valve Types 159

    13.1 Generic and specific classifications 159
        13.1.1 Valve classification description 159

14. Basic Damper Types 165

    14.1 Generic and specific classifications 165
        14.1.1 Damper classification descriptions 165

15. Basic Types of Construction Material 171

    15.1 Generic and specific classifications 171
        15.1.1 Base metals - construction material classification descriptions 171
        15.1.2 Plastics, ceramics and protective linings - construction material classification descriptions 177

16. Basic Fan Classifications 182

    16.1 Classifications 182
        16.1.1 Function 182

Appendix A - Report Writer Programs A-1

Appendix B - File Creation/File Manipulation B-1

Appendix C - TYMNET Diagnostic Messages C-1

Appendix D - SYSTEM 2000 Diagnostic Messages D-1

Appendix E - NTIS Application Form E-1

CONTENTS (continued)

Page

Appendix F - FGDIS Dump Program F-1

Appendix G - NCC Cost of Services G-1

Appendix H - Problem/Solution Access Codes H-1

Appendix I - Glossary of FGD Systems/FGDIS-Related Definitions I-1

FIGURES

Number		Page
1	FGDIS Structure Diagram	3
2	Venturi Tower Configurations Included in FGDIS	88
3	Spray Tower Types Included in FGDIS	90
4	Tray Tower and Tray Types	91
5	Packed Tower and Packing Types	92
6	Disc Contactor Type Impingement Tower with Cascading Baffle Disks and Rings	94
7	Mechanically-Aided Gas Sparger Tower	95
8	Four Basic Spray Dryer Types	97
9	Four Bulk Separation Type Precollectors Followed by a Conventional Primary Collector	101
10	Knock-Out Precollectors Included in FGDIS	102
11	Impingement Type Mist Eliminators	104
12	Centrifugal Type Mist Eliminators	105
13	Cyclonic Tower	106
14	In-Line Reheat System	110
15	Direct Combustion Reheat Systems	111
16	Indirect Hot Air Reheat System	113
17	Waste Heat Recovery Reheat System	114
18	Exit Gas Recirculation Reheat System	116
19	Flue Gas Bypass Reheat Systems	117
20	Gravity Type Thickener	120

FIGURES (continued)

Number		Page
21	Plate Type (Lamella) Thickener	123
22	Vacuum Filter Types Included in FGDIS	125
23	Cross-Section of Solid-Bowl Centrifuge	127
24	Hydroclone Solids Separator	129
25	Forced Oxidation System on a Bleed Stream from an FGD System	132
26	Fixation Alternatives	134
27	Stabilization Alternatives for Blending Non-Alkaline Flyash	136
28	Examples of Pond Types Included in FGDIS	140
29	Examples of Landfill Types Included in FGDIS	143
30	Typical Gypsum Stack Design	145
31	Wet Ball Mill Type Reagent Preparation Equipment	149
32	Slaker Type Reagent Preparation Equipment Included in FGDIS	151
33	Displacement Pumps	156
34	Centrifugal Pump	158
35	Valve Types Included in FGDIS	161
36	Louver Dampers	167
37	Guillotine Damper	169
38	Butterfly Damper	170
39	Fan Designs Included in FGDIS	185

TABLES

Number		Page
1	FGDIS Field Listing (Definition)	5
2	NCC Access Telephone Numbers	27
3	Terminal Identifiers	36
4	Regional Office Bin Number Assignments	82
5	Basic Scrubber/Absorber Types	86
6	Basic Mist Eliminator Types	99
7	Basic Reheater Types	108
8	Basic Solids Dewatering Device Types	119
9	Basic Sludge Processing Types	131
10	Sludge Disposal Site Types	139
11	Basic Reagent Preparation Equipment Types	147
12	Basic Pump Types	154
13	Basic Valve Types	160
14	Basic Damper Types	166
15	Basic Types of Construction Materials	172
16	Nominal Chemical Composition of Base Metals	176
17	Organic Linings: Base Materials and Resistance to Some Environments	178
18	Basic Fan Classifications	183

INTRODUCTION

This document was assembled as a user's manual and reference book/primer for Flue Gas Desulfurization Information System (FGDIS) users and recipients of the Utility FGD Survey quarterly report. The text is divided into two parts. Part I is the Interactive Computer Procedures for the FGDIS. This section specifically addresses the use of and terminology related to the use of the computerized data base. Part II is the FGDIS Terminology. This section addresses FGD technology as it relates to this particular computerized data base. The primary thrust of Part II concerns the equipment/component classifications. Major equipment items and construction materials are broken down into primary, secondary, and tertiary categories referred to as generic type, specific type, and trade/common name or common design. This is supported by an appendix that describes the use of the problem/solution codes. A glossary defining common scrubber and boiler-related FGD terms is also addressed in this document. The glossary includes definitions for particular data field titles in FGDIS that may be unclear to new FGDIS users and individuals somewhat detached from the system.

This publication replaces the FGDIS User's Manual dated October 1982 available through the National Technical Information Service (NTIS No. PB83146209).

I. INTERACTIVE COMPUTER PROCEDURES FOR THE FLUE GAS DESULFURIZATION INFORMATION SYSTEM (FGDIS)

SECTION 1

GENERAL INFORMATION

This manual is a guide to the use of the Flue Gas Desulfurization Information System (FGDIS), a collection of data base files stored at the National Computer Center (NCC) in Research Triangle Park, North Carolina. Access to these files and manipulation of the data therein are accomplished via SYSTEM 2000, a general data base management system developed by INTEL Corporation and supported by NCC Univac 1100 hardware. Other user's manuals relevant to use of this system are as follows:

- SYSTEM 2000® Reference Manual. This manual (available through INTEL Corporation, Austin, Texas) provides in-depth information on the use of SYSTEM 2000. Sections of this manual that are concerned with the Immediate Access and Report Writer features of SYSTEM 2000 have been reproduced herein, courtesy of INTEL.
- NCC User Reference Manual. This manual, which was prepared for the U.S. Environmental Protection Agency (EPA) by SDC Integrated Services, Inc., provides in-depth descriptions of the Univac 1100 Executive Control Language.

The documentation symbols listed and defined here are used throughout this manual. These symbols do not appear in actual commands or output; they document conventions only.

< >	The enclosed item is a user-supplied value.
[ ]	The enclosed item is mandatory. When a choice of values is shown, the user must specify one of them.
{ }	The enclosed item is optional and has a default setting if no user specification is made.
Δ	Designates a blank.

SECTION 2

DATA BASE STRUCTURE

2.1 STRUCTURE DIAGRAM

The Flue Gas Desulfurization Information System (FGDIS) data base is a collection of data files pertaining to the design and performance of flue gas desulfurization (FGD) systems. The data are stored in the form of logical entries (elements) linked together by a common structure consisting of various levels of repeating groups (or levels of information). The structure diagram (Figure 1) shows the various repeating groups of the FGDIS, the hierarchy associated with each, and some of the key data items included in each group. Level zero, which is at the top, consists of a single repeating group containing general plant information. Level one (immediately below level zero) consists of six groups. Level one is followed by level two, and so on. As the diagram shows, a group number is associated with each repeating group except the level zero group. Elements residing at level zero are part of an assumed repeating group called "ENTRY."

A "data tree" is defined as any repeating group at a given level plus all its direct descendant repeating groups. Referring again to Figure 1, an example of a data tree would be the tree beginning with the Boiler-Stack group and ending with the Fuel group. In this instance, the Fuel group is a direct descendant of the Boiler-Stack group.

2.2 FIELD LISTING ("DESCRIBE" OUTPUT)

Within each repeating group of the data base is a series of elements (or components). Some of these are indicated in Figure 1. Each element represents a piece of data stored within that group that is consistent with the repeating group designation. Each element consists of three major components as shown here:

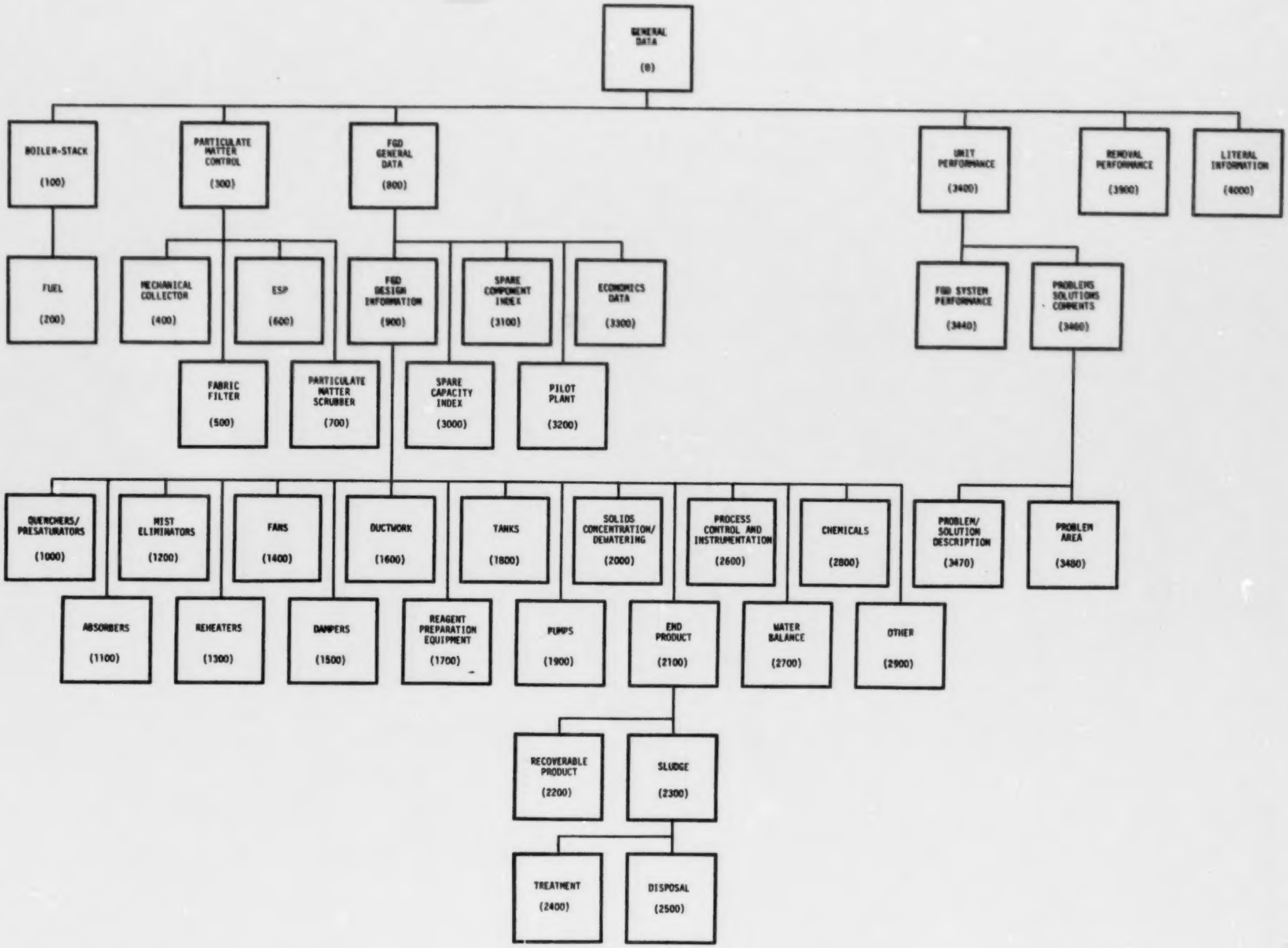
GENERAL DATA (0)
BOILER-STACK (100)
PARTICULATE MATTER CONTROL (300)
FGD GENERAL DATA (800)
UNIT PERFORMANCE (3400)
REMOVAL PERFORMANCE (3900)
LITERAL INFORMATION (4000)
FUEL (200)
MECHANICAL COLLECTOR (400)
ESP (600)
FGD DESIGN INFORMATION (900)
SPARE COMPONENT INDEX (3100)
ECONOMICS DATA (3300)
FGD SYSTEM PERFORMANCE (3440)
PROBLEMS SOLUTIONS COMMENTS (3460)
FABRIC FILTER (500)
PARTICULATE MATTER SCRUBBER (700)
SPARE CAPACITY INDEX (3000)
PILOT PLANT (3200)
QUENCHERS/ PRESATURATORS (1000)
MIST ELIMINATORS (1200)
FANS (1400)
DUCTWORK (1600)
TANKS (1800)
SOLIDS CONCENTRATION/ DEWATERING (2000)
PROCESS CONTROL AND INSTRUMENTATION (2600)
CHEMICALS (2800)
PROBLEM/ SOLUTION DESCRIPTION (3470)
PROBLEM AREA (3480)
ABSORBERS (1100)
REHEATERS (1300)
DAMPERS (1500)
REAGENT PREPARATION EQUIPMENT (1700)
PUMPS (1900)
END PRODUCT (2100)
WATER BALANCE (2700)
OTHER (2900)
RECOVERABLE PRODUCT (2200)
SLUDGE (2300)
TREATMENT (2400)
DISPOSAL (2500)

Figure 1. FGDIS structure diagram.

ELEMENT NUMBER * ELEMENT NAME (ELEMENT DESIGNATION)

The unique Element Number associated with each element is used for identification purposes. This number is followed by the system separator (*), which separates the Element Number from the Element Name. The Element Name identifies the piece of data that is stored (or can be stored) within the element. In the case of repeating groups, the Element Name is the name assigned to the respective group. The Element Designation contains a Data Type Designation, a Picture Designation, and a Repeating Group Relationship. The Data Type Designation specifies whether the element is a DECIMAL field, INTEGER field, NAME field, or TEXT field. DECIMAL, INTEGER, and TEXT fields are self-explanatory. A NAME field consists of any alphanumeric data from which all leading, trailing, and extraneous (more than one) embedded blanks are discarded once the piece of data is stored. The Picture Designation is the field size specification for the information that is stored within the element. The following notational conventions are used:

X = symbol for an alphanumeric character for NAME and TEXT data types

9 = symbol for a numeric character for INTEGER and DECIMAL data types

XX or 99 = symbol for two characters

X(n) or 9(n) = symbol for the number of characters specified by (n)

Following the Picture Designation is the Repeating Group Relationship that specifies the repeating group of which the element is a member.

Table 1 presents the complete FGDIS definition, including all repeating groups and the elements therein. This definition was produced by using the DESCRIBE command (Section 3.3.1).

TABLE 1. FGDIS FIELD LISTING (DEFINITION)

```
    1*  IDENTIFICATION NUMBER (INTEGER NUMBER 999)
    2*  FOREIGN - DOMESTIC (CHAR X(8))
    3*  UTILITY - INDUSTRIAL (CHAR X(8))
    4*  SO2 & PARTICLE/PARTICLE (CHAR X(8))
    5*  COMPANY NAME (CHAR X(8))
    6*  ASSOCIATED UTILITIES (CHAR X(8))
    7*  PLANT NAME (CHAR X(8))
    8*  UNIT NUMBER (CHAR X(8))
    9*  PLANT ADDRESS (CHAR X(8))
   10*  PLANT CITY (CHAR X(8))
   11*  PLANT COUNTY (CHAR X(8))
   12*  PLANT STATE/COUNTRY (CHAR X(8))
   13*  PLANT ZIPCODE (INTEGER NUMBER 9(5))
   14*  PLANT EPA REGION (INTEGER NUMBER 99)
   15*  PLANT RIVER BASIN (CHAR X(8))
   16*  GENERIC REGULATORY CLASSIFICATION - A/B/C/D/E/F/G (CHAR X(8))
   17*  PARTICLE EMISSION LIMITATION - LB/MM BTU (DECIMAL NUMBER 99.99
        9)
   18*  SO2 EMISSION LIMITATION - LB/MM BTU (DECIMAL NUMBER 99.999)
   19*  NOX EMISSION LIMITATION - LB/MM BTU (DECIMAL NUMBER 9.999)
   20*  OPACITY LIMITATION - % (DECIMAL NUMBER 999.99)
   21*  NET PLANT GENERATING CAPACITY - MW (INTEGER NUMBER 9999)
   22*  GROSS UNIT GENERATING CAPACITY - MW (INTEGER NUMBER 9999)
   23*  NET UNIT GENERATING CAPACITY WITH FGD - MW (INTEGER NUMBER 999
        9)
   24*  NET UNIT GENERATING CAPACITY W/O FGD - MW (INTEGER NUMBER 9999
        )
   25*  EQUIVALENT SCRUBBED CAPACITY - MW (INTEGER NUMBER 9999)
   26*  SPECIFIC REGULATORY CLASSIFICATION - FEDERAL [PSD]/STATE/COUNT
        Y/CITY/ ETC. (CHAR X(8))
  100*  UNIT DATA - BOILER & STACK (RECORD)
    101*  BOILER SUPPLIER (CHAR X(8) IN 100)
    102*  BOILER TYPE - PULVERIZED COAL/ETC (CHAR X(8) IN 100)
    103*  BOILER FIRING METHOD - TANGENTIAL/ETC (CHAR X(8) IN 100)
    104*  BOILER - WET BOTTOM/DRY BOTTOM (CHAR X(8) IN 100)
    105*  BOILER DRAFT - FORCED/INDUCED/BALANCED (CHAR X(8) IN 100)
    106*  BOILER SERVICE LOAD - BASE/PEAK/ETC (CHAR X(8) IN 100)
    107*  BOILER COMMERCIAL SERVICE DATE - YYMM (INTEGER NUMBER 9999 I
          N 100)
    108*  DESIGN BOILER FLUE GAS FLOW - ACFM (INTEGER NUMBER 9(7) IN 1
          00)
    109*  BOILER FLUE GAS TEMPERATURE - F (INTEGER NUMBER 9999 IN 100)

    110*  STACK FLUE GAS OXYGEN - % (DECIMAL NUMBER 999.9 IN 100)
    111*  BOILER HEAT RATE - BTU/KWH (INTEGER NUMBER 9(5) IN 100)
    112*  BOILER DESIGN FUEL FIRING RATE - TPH (INTEGER NUMBER 999 IN
          100)
    113*  BOILER EXCESS AIR - % (DECIMAL NUMBER 999.9 IN 100)
    114*  BOILER AVERAGE CAPACITY FACTOR - % (DECIMAL NUMBER 999.9 IN
          100)
    115*  STACK HEIGHT - FT (INTEGER NUMBER 9999 IN 100)
    116*  STACK SHELL MATERIAL (CHAR X(8) IN 100)
```

(continued)

TABLE 1 (continued)

117* STACK FLUE CONSTRUCTION MATERIAL GENERIC TYPE (CHAR X(8) IN 100)
118* STACK FLUE CONSTRUCTION MATERIAL SPECIFIC TYPE (CHAR X(8) IN 100)
119* STACK FLUE CONSTRUCTION MATERIAL COMMON NAME (CHAR X(8) IN 100)
120* STACK FLUE LINER CONSTRUCTION MATERIAL GENERIC TYPE (CHAR X(8) IN 100)
121* STACK FLUE LINER CONSTRUCTION MATERIAL SPECIFIC TYPE (CHAR X(8) IN 100)
122* STACK FLUE LINER CONSTRUCTION MATERIAL COMMON NAME (CHAR X(8) IN 100)
123* STACK TOP INNER DIAMETER - FT (DECIMAL NUMBER 999.9 IN 100)
124* STACK GAS INLET TEMPERATURE -F (INTEGER NUMBER 999 IN 100)
125* STACK GAS OUTLET VELOCITY - ACTUAL FPS (DECIMAL NUMBER 999.9 IN 100)
200* ACTUAL FUEL DATA (RECORD IN 100)
  201* FUEL TYPE (CHAR X(8) IN 200)
  202* FUEL GRADE - BITUMINOUS/SUBBITUMINOUS/ETC (CHAR X(8) IN 200)
  203* NAME OF FUEL SUPPLIER (CHAR X(8) IN 200)
  204* MINE NAME/AREA (CHAR X(8) IN 200)
  205* MINE STATE (CHAR X(8) IN 200)
  206* MINE COUNTY (CHAR X(8) IN 200)
  207* AVERAGE HEAT CONTENT - BTU/LB (INTEGER NUMBER 9(6) IN 200)

  208* RANGE HEAT CONTENT - BTU/LB (CHAR X(8) IN 200)
  209* AVERAGE ASH CONTENT - % (DECIMAL NUMBER 99.99 IN 200)
  210* RANGE ASH CONTENT - % (CHAR X(8) IN 200)
  211* AVERAGE MOISTURE CONTENT - % (DECIMAL NUMBER 99.99 IN 200)

  212* RANGE MOISTURE CONTENT - % (CHAR X(8) IN 200)
  213* AVERAGE SULFUR CONTENT - % (DECIMAL NUMBER 99.99 IN 200)
  214* RANGE SULFUR CONTENT - % (CHAR X(8) IN 200)
  215* AVERAGE CHLORIDE CONTENT - % (DECIMAL NUMBER 99.99 IN 200)

  216* RANGE CHLORIDE CONTENT - % (CHAR X(8) IN 200)
  217* FUEL ANALYSIS METHOD - AVERAGE/SPOT/TYPICAL (CHAR X(8) IN 200)
  218* FUEL ANALYSIS FREQUENCY - (CHAR X(8) IN 200)
300* PARTICLE CONTROL (RECORD)
  301* PARTICLE CONTROL CONFIGURATION - INTEGRATED/SEGREGATED (CHAR X(8) IN 300)
  302* PARTICLE CONTROL SPACE REQUIREMENTS - SQ FT (INTEGER NUMBER 9(7) IN 300)
  303* PARTICLE CONTROL MODE - ESP/FABRIC FILTER/PARTICLE SCRUBBER/ETC. (CHAR X(8) IN 300)
  400* MECHANICAL COLLECTOR (RECORD IN 300)
    401* NUMBER OF MECHANICAL COLLECTORS (INTEGER NUMBER 99 IN 400)

    402* MECHANICAL COLLECTOR NUMBER OF SPARES (INTEGER NUMBER 99 IN 400)
    403* MECHANICAL COLLECTOR PLACED IN SERVICE - YYMM (INTEGER NUMBER 9999 IN 400)
    404* MECHANICAL COLLECTOR REMOVED FROM SERVICE - YYMM (INTEGER NUMBER 9999 IN 400)

(continued)

TABLE 1 (continued)

```
  405*  MECHANICAL COLLECTOR TYPE (CHAR X(8) IN 400)
  406*  MECHANICAL COLLECTOR SUPPLIER (CHAR X(8) IN 400)
  407*  MECHANICAL COLLECTOR INLET FLUE GAS CAPACITY - ACFM (INTEG
        ER NUMBER 9(9) IN 400)
  408*  MECHANICAL COLLECTOR INLET FLUE GAS TEMPERATURE - F (INTEG
        ER NUMBER 9(5) IN 400)
  409*  MECHANICAL COLLECTOR PRESSURE DROP - IN H2O (DECIMAL NUMBE
        R 99.99 IN 400)
  410*  MECHANICAL COLLECTOR PART OUTLET LOAD - GR/SCF (DECIMAL NU
        MBER 999.99 IN 400)
  411*  MECHANICAL COLLECTOR PART REMOVAL EFFICIENCY - % (DECIMAL
        NUMBER 999.99 IN 400)
500*  FABRIC FILTER (RECORD IN 300)
  501*  NUMBER OF FABRIC FILTERS (INTEGER NUMBER 99 IN 500)
  502*  FABRIC FILTER PLACED IN SERVICE - YYMM (INTEGER NUMBER 999
        9 IN 500)
  503*  FABRIC FILTER REMOVED FROM SERVICE - YYMM (INTEGER NUMBER
        9999 IN 500)
  504*  FABRIC FILTER TYPE - PULSE JET/REVERSE AIR/SHAKE (CHAR X(8
        ) IN 500)
  505*  FABRIC FILTER SUPPLIER (CHAR X(8) IN 500)
  506*  FABRIC FILTER NUMBER OF COMPARTMENTS (INTEGER NUMBER 9999
        IN 500)
  507*  FABRIC FILTER NUMBER OF SPARE COMPARTMENTS (INTEGER NUMBER
         999 IN 500)
  508*  FABRIC FILTER INLET FLUE GAS CAPACITY - ACFM (INTEGER NUMB
        ER 9(9) IN 500)
  509*  FABRIC FILTER INLET FLUE GAS TEMPERATURE - F (INTEGER NUMB
        ER 9(5) IN 500)
  510*  FABRIC FILTER PRESSURE DROP - IN H2O (DECIMAL NUMBER 99.99
         IN 500)
  511*  FABRIC FILTER PART OUTLET LOAD - GR/SCF (DECIMAL NUMBER 99
        9.99 IN 500)
  512*  FABRIC FILTER PART REMOVAL EFFICIENCY - % (DECIMAL NUMBER
        999.9 IN 500)
  513*  FABRIC FILTER TYPICAL GAS/CLOTH RATIO - FT/MIN (DECIMAL NU
        MBER 9.99 IN 500)
  514*  FABRIC FILTER MAX GAS/CLOTH RATIO - FT/MIN (DECIMAL NUMBER
         99.9 IN 500)
  515*  FABRIC FILTER BAG FABRIC (CHAR X(8) IN 500)
  516*  FABRIC FILTER FABRIC COATING (CHAR X(8) IN 500)
600*  ESP (RECORD IN 300)
  601*  NUMBER OF ESPS (INTEGER NUMBER 99 IN 600)
  602*  ESP NUMBER OF SPARES (INTEGER NUMBER 99 IN 600)
  603*  ESP PLACED IN SERVICE - YYMM (INTEGER NUMBER 9999 IN 600)
  604*  ESP REMOVED FROM SERVICE - YYMM (INTEGER NUMBER 9999 IN 60
        0)
  605*  ESP TYPE - HOT SIDE/COLD SIDE (CHAR X(8) IN 600)
  606*  ESP SUPPLIER (CHAR X(8) IN 600)
  607*  ESP INLET FLUE GAS CAPACITY - ACFM (INTEGER NUMBER 9(9) IN
         600)
  608*  ESP INLET FLUE GAS TEMPERATURE - F (INTEGER NUMBER 9(5) IN
         600)
  609*  ESP PRESSURE DROP - IN H2O (DECIMAL NUMBER 99.99 IN 600)
```

(continued)

TABLE 1 (continued)

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  610*  ESP PART OUTLET LOAD - GR/SCF (DECIMAL NUMBER 999.99 IN 60
        0)
  611*  ESP PART REMOVAL EFFICIENCY - % (DECIMAL NUMBER 999.9 IN 6
        00)
  612*  ESP FLUE GAS CONDITIONING TYPE (CHAR X(8) IN 600)
700*  PARTICLE SCRUBBER (RECORD IN 300)
  701*  NUMBER OF PART SCRUBBERS (INTEGER NUMBER 99 IN 700)
  702*  PART SCRUBBER NUMBER OF SPARES (INTEGER NUMBER 99 IN 700)
  703*  PART SCRUBBER PLACED IN SERVICE - YYMM (INTEGER NUMBER 999
        9 IN 700)
  704*  PART SCRUBBER REMOVED FROM SERVICE - YYMM (INTEGER NUMBER
        9999 IN 700)
  705*  PART SCRUBBER GENERIC TYPE (CHAR X(8) IN 700)
  706*  PART SCRUBBER SPECIFIC TYPE (CHAR X(8) IN 700)
  707*  PART SCRUBBER TRADE NAME (CHAR X(8) IN 700)
  708*  PART SCRUBBER SUPPLIER (CHAR X(8) IN 700)
  709*  PART SCRUBBER DIMENSIONS - FT (CHAR X(8) IN 700)
  710*  PART SCRUBBER SHELL CONSTRUCTION MATERIAL GENERIC TYPE (CH
        AR X(8) IN 700)
  711*  PART SCRUBBER SHELL CONSTRUCTION MATERIAL SPECIFIC TYPE (C
        HAR X(8) IN 700)
  712*  PART SCRUBBER SHELL CONSTRUCTION MATERIAL COMMON NAME (CHA
        R X(8) IN 700)
  713*  PART SCRUBBER LINER CONSTRUCTION MATERIAL GENERIC TYPE (CH
        AR X(8) IN 700)
  714*  PART SCRUBBER LINER CONSTRUCTION MATERIAL SPECIFIC TYPE (C
        HAR X(8) IN 700)
  715*  PART SCRUBBER LINER CONSTRUCTION MATERIAL COMMON NAME (CHA
        R X(8) IN 700)
  716*  PART SCRUBBER % OF BOILER LOAD (DECIMAL NUMBER 999.9 IN 70
        0)
  717*  PART SCRUBBER GAS CONTACTING DEVICE TYPE (CHAR X(8) IN 700
        )
  718*  PART SCRUBBER NUMBER OF GAS CONTACTING ZONES (INTEGER NUMB
        ER 999 IN 700)
  719*  PART SCRUBBER DISTANCE BETWEEN GAS CONTACTING ZONES - IN (
        DECIMAL NUMBER 99.99 IN 700)
  720*  PART SCRUBBER NUMBER OF SPRAY HEADERS (INTEGER NUMBER 9999
         IN 700)
  721*  PART SCRUBBER NOZZLE MATERIAL - (CHAR X(8) IN 700)
  722*  PART SCRUBBER NOZZLE PRESSURE DROP - PSI (DECIMAL NUMBER 9
        99.99 IN 700)
  723*  PART SCRUBBER LIQUID REICRCULATION RATE - GPM (INTEGER NUM
        BER 9(6) IN 700)
  724*  PART SCRUBBER L/G RATIO - GAL/1000 ACF (DECIMAL NUMBER 99.
        9 IN 700)
  725*  PART SCRUBBER PH CONTROL ADDITIVE (CHAR X(8) IN 700)
  726*  PART SCRUBBER GAS-SIDE PRESSURE DROP - IN H2O (DECIMAL NUM
        BER 99.99 IN 700)
  727*  PART SCRUBBER SUPERFICIAL GAS VELOCITY - FT/SEC (DECIMAL N
        UMBER 9(9).9 IN 700)
  728*  PART SCRUBBER INLET GAS FLOW RATE - ACFM (INTEGER NUMBER 9
        (9) IN 700)
  729*  PART SCRUBBER INLET GAS TEMPERATURE - F (INTEGER NUMBER 9(
        5) IN 700)
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(continued)

TABLE 1 (continued)

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    730*  PART SCRUBBER INLET SO2 LEVEL - PPM (DECIMAL NUMBER 9999.9
          99 IN 700)
    731*  PART SCRUBBER INLET SO2 LEVEL - LB/MM BTU (DECIMAL NUMBER
          999.999 IN 700)
    732*  PART SCRUBBER INLET PART LEVEL - GR/SCF (DECIMAL NUMBER 99
          9.999 IN 700)
    733*  PART SCRUBBER INLET PART LEVEL - LB/MM BTU (DECIMAL NUMBER
          9(5).999 IN 700)
    734*  PART SCRUBBER OUTLET GAS FLOW RATE - ACFM (INTEGER NUMBER
          9(9) IN 700)
    735*  PART SCRUBBER OUTLET GAS TEMPERATURE - F (INTEGER NUMBER 9
          (5) IN 700)
    736*  PART SCRUBBER OUTLET SO2 LEVEL - PPM (DECIMAL NUMBER 9(5).
          999 IN 700)
    737*  PART SCRUBBER OUTLET SO2 LEVEL - LB/MM BTU (DECIMAL NUMBER
          999.999 IN 700)
    738*  PART SCRUBBER OUTLET PART LEVEL - GR/SCF (DECIMAL NUMBER 9
          9.999 IN 700)
    739*  PART SCRUBBER OUTLET PART LEVEL - LB/MM BTU (DECIMAL NUMBE
          R 9(5).999 IN 700)
    740*  PART SCRUBBER SO2 REMOVAL EFFICIENCY - % (DECIMAL NUMBER 9
          9.9 IN 700)
    741*  PART SCRUBBER PART REMOVAL EFFICIENCY - % (DECIMAL NUMBER
          999.9 IN 700)
800*  FGD SYSTEM (RECORD)
  801*  SALEABLE PRODUCT/THROWAWAY PRODUCT (CHAR X(8) IN 800)
  802*  SO2 REMOVAL MODE - WET SCRUBBING/SPRAY DRYING (CHAR X(8) IN
        800)
  803*  PROCESS TYPE - LIME/LIMESTONE/ETC (CHAR X(8) IN 800)
  804*  PROCESS ADDITIVES - MG/ADIPIC ACID/ETC (CHAR X(8) IN 800)
  805*  FGD SYSTEM SUPPLIER (CHAR X(8) IN 800)
  806*  A-E FIRM (CHAR X(8) IN 800)
  807*  CONSTRUCTION FIRM (CHAR X(8) IN 800)
  808*  FGD DEVELOPMENT LEVEL - FULL SCALE/DEMONSTRATION/PROTOTYPE (
        CHAR X(8) IN 800)
  809*  NEW/RETROFIT (CHAR X(8) IN 800)
  810*  TOTAL UNIT DESIGN PARTICLE REMOVAL EFFICIENCY - % (DECIMAL N
        UMBER 99.99 IN 800)
  811*  TOTAL UNIT SO2 DESIGN REMOVAL EFFICIENCY - % (DECIMAL NUMBER
        99.99 IN 800)
  812*  FGD CURRENT STATUS - 1/2/3/4/5/6/7/8 (INTEGER NUMBER 99 IN 8
        00)
  813*  FGD TERMINATION DATE - YYMM (INTEGER NUMBER 9999 IN 800)
  814*  FGD COMMERCIAL START-UP - YYMM (INTEGER NUMBER 9999 IN 800)
  815*  FGD INITIAL START-UP - YYMM (INTEGER NUMBER 9999 IN 800)
  816*  FGD CONSTRUCTION COMPLETION - YYMM (INTEGER NUMBER 9999 IN 8
        00)
  817*  FGD CONSTRUCTION INITIATION - YYMM (INTEGER NUMBER 9999 IN 8
        00)
  818*  FGD CONTRACT AWARDED - YYMM (INTEGER NUMBER 9999 IN 800)
  819*  FGD LETTER OF INTENT SIGNED - YYMM (INTEGER NUMBER 9999 IN 8
        00)
  820*  FGD INITIATED BID REQUEST - YYMM (INTEGER NUMBER 9999 IN 800
        )
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(continued)

TABLE 1 (continued)

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821*  FGD INITIATED PRELIMINARY DESIGN - YYMM (INTEGER NUMBER 9999
       IN 800)
822*  FGD TECHNOLOGY LEVEL [GENERATION] - 1/2/3/4 (INTEGER NUMBER
      99 IN 800)
900*  FGD DESIGN & OPERATING PARAMETERS (RECORD IN 800)
  901*  DESIGN COAL SULFUR CONTENT - % (DECIMAL NUMBER 99.99 IN 90
        0)
  902*  DESIGN COAL HEAT CONTENT - BTU/LB (INTEGER NUMBER 9(6) IN
        900)
  903*  DESIGN COAL ASH CONTENT - % (DECIMAL NUMBER 99.99 IN 900)
  904*  DESIGN COAL MOISTURE CONTENT - % (DECIMAL NUMBER 99.99 IN
        900)
  905*  DESIGN COAL CHLORIDE CONTENT - % (DECIMAL NUMBER 99.99 IN
        900)
  906*  FGD SYSTEM SPACE REQUIREMENTS - SQ FT (INTEGER NUMBER 9(7)
         IN 900)
  907*  FGD SYSTEM TURNDOWN RATIO (CHAR X(8) IN 900)
  908*  FGD SYSTEM TURNDOWN METHOD - (CHAR X(8) IN 900)
  909*  FGD SYSTEM PRESSURE DROP - IN H2O (DECIMAL NUMBER 99.99 IN
         900)
  910*  OVERALL FGD SYSTEM OXIDATION - % (DECIMAL NUMBER 999.9 IN
        900)
  911*  FGD SYSTEM SCRUBBER RECYCLE LIQUOR - % SOLIDS (DECIMAL NUM
        BER 99.99 IN 900)
  912*  FGD SYSTEM ABSORBER RECYCLE LIQUOR - % SOLIDS (DECIMAL NUM
        BER 99.99 IN 900)
  913*  FGD SYSTEM BYPASS CAPABILITY - YES/NO (CHAR X(8) IN 900)
  914*  RESTRICTIONS TO USING BYPASS (CHAR X(8) IN 900)
  915*  TIME SCHEDULE FOR REDUCED BOILER LOAD (CHAR X(8) IN 900)
  916*  FGD SYSTEM OPERATION & MAINTENANCE REQUIREMENTS - MANHOURS
        /DAY (DECIMAL NUMBER 999.9 IN 900)
  917*  FGD SYSTEM OPERATION & MAINTENANCE REQUIREMENTS - OPERATOR
        S/SHIFT (INTEGER NUMBER 99 IN 900)
  918*  FGD SYSTEM OPERATION & MAINTENANCE REQUIREMENTS - MAINTENA
        NCE PERSONNEL/ SHIFT (INTEGER NUMBER 999 IN 900)
  919*  FGD SYSTEM OPERATION/MAINTENANCE REQUIREMENT - MAINTENANCE
         SHIFTS/DAY - (INTEGER NUMBER 9 IN 900)
  920*  FGD SYSTEM OPERATIONAL/MAINTNENACE REQUIREMENT - ESTIMATED
         OPERATOR MANHOURS/YEAR (INTEGER NUMBER 9999 IN 900)
  921*  FGD SYSTEM OPERATION/MAINTENANCE REQUIREMENT - ESTIMATED M
        AINTENANCE MANHOURS/YEAR (INTEGER NUMBER 9999 IN 900)
  922*  TYPE OF FGD SYSTEM MAINTENANCE CREW - DEDICATED/ETC (CHAR
        X(8) IN 900)
  923*  TYPE OF MAINTENANCE SUPERVISORS - DEDICATED/ETC (CHAR X(8)
         IN 900)
  924*  FGD SYSTEM MAINTENANCE RESPONSIBILITY LEVEL - IDENTICAL TO
         BOILER/LOWER/ HIGHER (CHAR X(8) IN 900)
 1000*  QUENCHER/PRESATURATOR (RECORD IN 900)
   1001*  NUMBER OF QUENCHERS/PRESATURATORS (INTEGER NUMBER 99 IN
          1000)
   1002*  QUENCHER/PRESATURATOR NUMBER OF SPARES (INTEGER NUMBER 9
          9 IN 1000)
   1003*  QUENCHER/PRESATURATOR PLACED IN SERVICE - YYMM (INTEGER
          NUMBER 9999 IN 1000)
   1004*  QUENCHER/PRESATURATOR REMOVED FROM SERVICE - YYMM (INTEG
          ER NUMBER 9999 IN 1000)
   1005*  QUENCHER/PRESATURATOR TYPE (CHAR X(8) IN 1000)
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(continued)

TABLE 1 (continued)

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  1006*  QUENCHER/PRESATURATOR LOCATION (CHAR X(8) IN 1000)
  1007*  QUENCHER/PRESATURATOR SUPPLIER (CHAR X(8) IN 1000)
  1008*  QUENCHER/PRESATURATOR INLET GAS FLOW - ACFM (INTEGER NUM
         BER 9(9) IN 1000)
  1009*  QUENCHER/PRESATURATOR INLET GAS TEMPERATURE - F (INTEGER
          NUMBER 9(9) IN 1000)
  1010*  QUENCHER/PRESATURATOR PRESSURE DROP - IN H2O (DECIMAL NU
         MBER 99.9 IN 1000)
  1011*  QUENCHER/PRESATURATOR LIQUID TYPE - MAKEUP WATER/RECLAIM
         ED WATER/ ABSORBER SLURRY/ETC (CHAR X(8) IN 1000)
  1012*  QUENCHER/PRESATURATOR LIQUID RECIRCULATION RATE - GPM (I
         NTEGER NUMBER 9(6) IN 1000)
  1013*  QUENCHER/PRESATURATOR L/G RATIO - GAL/1000 ACF (DECIMAL
         NUMBER 99.9 IN 1000)
  1014*  QUENCHER/PRESATURATOR NUMBER OF SPRAY HEADERS (INTEGER N
         UMBER 9999 IN 1000)
  1015*  QUENCHER/PRESATURATOR NOZZLE MATERIAL (CHAR X(8) IN 1000
         )
  1016*  QUENCHER/PRESATURATOR NOZZLE PRESSURE DROP - PSI (DECIMA
         L NUMBER 99.99 IN 1000)
  1017*  QUENCHER/PRESATURATOR CONSTRUCTION MATERIAL GENERIC TYPE
          (CHAR X(8) IN 1000)
  1018*  QUENCHER/PRESATURATOR CONSTRUCTION MATERIAL SPECIFIC TYP
         E (CHAR X(8) IN 1000)
  1019*  QUENCHER/PRESATURATOR CONSTRUCTION MATERIAL COMMON NAME
         (CHAR X(8) IN 1000)
  1020*  QUENCHER/PRESATURATOR LINER MATERIAL GENERIC TYPE (CHAR
         X(8) IN 1000)
  1021*  QUENCHER/PRESATURATOR LINER MATERIAL SPECIFIC TYPE (CHAR
          X(8) IN 1000)
  1022*  QUENCHER/PRESATURATOR LINER MATERIAL COMMON NAME (CHAR X
         (8) IN 1000)
1100*  ABSORBER (RECORD IN 900)
  1101*  NUMBER OF ABSORBERS (INTEGER NUMBER 99 IN 1100)
  1102*  ABSORBER NUMBER OF SPARES (INTEGER NUMBER 99 IN 1100)
  1103*  ABSORBER PLACED IN SERVICE - YYMM (INTEGER NUMBER 9999 I
         N 1100)
  1104*  ABSORBER REMOVED FROM SERVICE - YYMM (INTEGER NUMBER 999
         9 IN 1100)
  1105*  ABSORBER GENERIC TYPE (CHAR X(8) IN 1100)
  1106*  ABSORBER SPECIFIC TYPE (CHAR X(8) IN 1100)
  1107*  ABSORBER TRADE NAME (CHAR X(8) IN 1100)
  1108*  ABSORBER SUPPLIER (CHAR X(8) IN 1100)
  1109*  ABSORBER DIMENSIONS - FT (CHAR X(8) IN 1100)
  1110*  ABSORBER SHELL CONSTRUCTION MATERIAL GENERIC TYPE (CHAR
         X(8) IN 1100)
  1111*  ABSORBER SHELL CONSTRUCTION MATERIAL SPECIFIC TYPE (CHAR
          X(8) IN 1100)
  1112*  ABSORBER SHELL CONSTRUCTION MATERIAL COMMON NAME (CHAR X
         (8) IN 1100)
  1113*  ABSORBER LINER CONSTRUCTION MATERIAL GENERIC TYPE (CHAR
         X(8) IN 1100)
  1114*  ABSORBER LINER CONSTRUCTION MATERIAL SPECIFIC TYPE (CHAR
          X(8) IN 1100)
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(continued)

TABLE 1 (continued)

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  1115*  ABSORBER LINER CONSTRUCTION MATERIAL COMMON NAME (CHAR X
         (8) IN 1100)
  1116*  ABSORBER % OF BOILER LOAD (DECIMAL NUMBER 999.9 IN 1100)

  1117*  ABSORBER GAS CONTACTING DEVICE TYPE (CHAR X(8) IN 1100)
  1118*  ABSORBER NUMBER OF GAS CONTACTING ZONES (INTEGER NUMBER
         999 IN 1100)
  1119*  ABSORBER DISTANCE BETWEEN GAS CONTACTING ZONES - IN (DEC
         IMAL NUMBER 99.99 IN 1100)
  1120*  ABSORBER NUMBER OF SPRAY HEADERS (INTEGER NUMBER 9999 IN
          1100)
  1121*  ABSORBER LIQUID RECIRCULATION RATE - GPM (INTEGER NUMBER
          9(6) IN 1100)
  1122*  ABSORBER L/G RATIO - GAL/1000ACF (DECIMAL NUMBER 99.9 IN
          1100)
  1123*  ABSORBER GAS-SIDE PRESSURE DROP - IN H20 (DECIMAL NUMBER
          99.99 IN 1100)
  1124*  ABSORBER SUPERFICIAL GAS VELOCITY - FT/SEC (DECIMAL NUMB
         ER 9(9).9 IN 1100)
  1125*  ABSORBER INLET GAS FLOW RATE - ACFM (INTEGER NUMBER 9(9)
          IN 1100)
  1126*  ABSORBER INLET GAS TEMPERATURE - F (INTEGER NUMBER 9(5)
         IN 1100)
  1127*  ABSORBER INLET SO2 LEVEL - PPM (DECIMAL NUMBER 9999.999
         IN 1100)
  1128*  ABSORBER INLET SO2 LEVEL - LB/MM BTU (DECIMAL NUMBER 999
         .999 IN 1100)
  1129*  ABSORBER INLET PART LEVEL - GR/SCF (DECIMAL NUMBER 999.9
         99 IN 1100)
  1130*  ABSORBER INLET PART LEVEL - LB/MM BTU (DECIMAL NUMBER 9(
         5).999 IN 1100)
  1131*  ABSORBER OUTLET GAS FLOW RATE - ACFM (INTEGER NUMBER 9(9
         ) IN 1100)
  1132*  ABSORBER OUTLET GAS TEMPERATURE - F (INTEGER NUMBER 9(5)
          IN 1100)
  1133*  ABSORBER OUTLET SO2 LEVEL - PPM (DECIMAL NUMBER 9(5).999
          IN 1100)
  1134*  ABSORBER OUTLET SO2 LEVEL - LB/MM BTU (DECIMAL NUMBER 99
         9.999 IN 1100)
  1135*  ABSORBER OUTLET PART LEVEL - GR/SCF (DECIMAL NUMBER 99.9
         99 IN 1100)
  1136*  ABSORBER OUTLET PART LEVEL - LB/MM BTU (DECIMAL NUMBER 9
         (5).999 IN 1100)
  1137*  ABSORBER SO2 REMOVAL EFFICIENCY - % (DECIMAL NUMBER 99.9
          IN 1100)
  1138*  ABSORBER PART REMOVAL EFFICIENCY - % (DECIMAL NUMBER 999
         .9 IN 1100)
  1139*  ABSORBER TURNDOWN RATIO (CHAR X(8) IN 1100)
  1140*  ABSORBER TURNDOWN METHOD (CHAR X(8) IN 1100)
  1141*  ABSORBER NOZZLE CONSTRUCTION MATERIAL TYPE (CHAR X(8) IN
          1100)
  1142*  ABSORBER NOZZLE PRESSURE DROP - IN H20 (DECIMAL NUMBER 9
         9.99 IN 1100)
1200*  MIST ELIMINATOR (RECORD IN 900)
```

(continued)

TABLE 1 (continued)

1201* ME FUNCTION - PRECOLLECTOR/PRIMARY COLLECTOR (CHAR X(8) IN 1200)
1202* TOTAL NUMBER OF ME'S - PER SYSTEM (INTEGER NUMBER 99 IN 1200)
1203* TOTAL NUMBER OF ME SPARES - PER SYSTEM (INTEGER NUMBER 9 IN 1200)
1204* NUMBER OF ME'S PER MODULE (INTEGER NUMBER 99 IN 1200)
1205* ME PLACED IN SERVICE - YYMM (INTEGER NUMBER 9999 IN 1200)
1206* ME REMOVED FROM SERVICE - YYMM (INTEGER NUMBER 9999 IN 1200)
1207* ME GENERIC TYPE - BULK SEPARATION/IMPINGEMENT/CENTRIFUGAL/ETC (CHAR X(8) IN 1200)
1208* ME SPECIFIC TYPE - WASH TRAY/MESH/BAFFLE/RADIAL VANE/ETC (CHAR X(8) IN 1200)
1209* ME TRADE/COMMON NAN+ME - VALVE [BUBBLE CAP] TRAY/GULL WING/CLOSED VANE/ETC (CHAR X(8) IN 1200)
1210* ME MANUFACTURER (CHAR X(8) IN 1200)
1211* ME CONFIGURATION - HORIZONTAL/VERTICAL (CHAR X(8) IN 1200)
1212* ME SHAPE - Z-SHAPE/A-FRAME (CHAR X(8) IN 1200)
1213* ME NUMBER OF STAGES (INTEGER NUMBER 99 IN 1200)
1214* ME NUMBER OF PASSES/STAGE (INTEGER NUMBER 99 IN 1200)
1215* ME FREEBOARD DISTANCE - FT (DECIMAL NUMBER 99.9 IN 1200)

1216* ME DISTANCE BETWEEN STAGES - IN (DECIMAL NUMBER 999.9 IN 1200)
1217* ME DISTANCE BETWEEN VANES - IN (DECIMAL NUMBER 99.9 IN 1200)
1218* ME VANE ANGLES - DEGREES (INTEGER NUMBER 999 IN 1200)
1219* ME PRESSURE DROP - IN H2O (DECIMAL NUMBER 99.9 IN 1200)
1220* ME SUPERFICIAL GAS VELOCITY - FT/SEC (DECIMAL NUMBER 999.9 IN 1200)
1221* ME CONSTRUCTION MATERIAL GENERIC TYPE (CHAR X(8) IN 1200)
1222* ME CONSTRUCTION MATERIAL SPECIFIC TYPE (CHAR X(8) IN 1200)
1223* ME CONSTRUCTION MATERIAL COMMON NAME (CHAR X(8) IN 1200)

1224* ME WASH WATER SOURCE - FRESH/BLENDED/SUPERNATANT (CHAR X(8) IN 1200)
1225* ME POINT OF WASH WATER COLLECTION (CHAR X(8) IN 1200)
1226* ME WASH DIRECTION - OVERSPRAY/UNDERSPRAY-FRONTSPRAY/BACKSPRAY (CHAR X(8) IN 1200)
1227* ME WASH FREQUENCY (CHAR X(8) IN 1200)
1228* ME WASH DURATION (CHAR X(8) IN 1200)
1229* ME WASH RATE - GAL/MIN (INTEGER NUMBER 9(5) IN 1200)
1230* ME WASH COVERAGE - GAL/MIN/SQ FT (INTEGER NUMBER 9(5) IN 1200)
1300* REHEATER (RECORD IN 900)
1301* NUMBER OF REHEATERS (INTEGER NUMBER 99 IN 1300)
1302* REHEATER NUMBER OF SPARES (INTEGER NUMBER 9 IN 1300)
1303* REHEATER NUMBER PER MODULE (INTEGER NUMBER 99 IN 1300)
1304* REHEATER PLACED IN SERVICE - YYMM (INTEGER NUMBER 9999 IN 1300)

(continued)

TABLE 1 (continued)

1305* REHEATER REMOVED FROM SERVICE - YYMM (INTEGER NUMBER 9999 IN 1300)
1306* REHEATER GENERIC TYPE - IN-LINE/INDIRECT HOT AIR/ETC (CHAR X(8) IN 1300)
1307* REHEATER SPECIFIC TYPE - STEAM/HOT WATER/ETC (CHAR X(8) IN 1300)
1308* REHEATER COMMON DESIGN - BARE TUBE/FIN TUBE/ETC (CHAR X(8) IN 1300)
1309* REHEATER COMBUSTION FUEL SULFUR CONTENT - % (DECIMAL NUMBER 99.9 IN 1300)
1310* REHEATER LOCATION (CHAR X(8) IN 1300)
1311* REHEATER % OF GAS BYPASSED (DECIMAL NUMBER 99.9 IN 1300)
1312* REHEATER TEMPERATURE INCREASE - F (INTEGER NUMBER 999 IN 1300)
1313* REHEATER INLET FLUE GAS FLOW RATE - ACFM (INTEGER NUMBER 9(9) IN 1300)
1314* REHEATER INLET FLUE GAS TEMPERATURE - F (INTEGER NUMBER 9999 IN 1300)
1315* REHEATER OUTLET FLUE GAS FLOW RATE - ACFM (INTEGER NUMBER 9(9) IN 1300)
1316* REHEATER OUTLET FLUE GAS TEMPERATURE - F (INTEGER NUMBER 9999 IN 1300)
1317* REHEATER NUMBER OF HEAT EXCHANGER BANKS (INTEGER NUMBER 9999 IN 1300)
1318* REHEATER NUMBER OF BUNDLES PER BANK (INTEGER NUMBER 99 IN 1300)
1319* REHEATER NUMBER OF TUBES PER BUNDLE (INTEGER NUMBER 999 IN 1300)
1320* REHEATER SELF CLEANING DEVICE TYPE (CHAR X(8) IN 1300)
1321* REHEATER CONSTRUCTION MATERIAL GENERIC TYPE (CHAR X(8) IN 1300)
1322* REHEATER CONSTRUCTION MATERIAL SPECIFIC TYPE (CHAR X(8) IN 1300)
1323* REHEATER CONSTRUCTION MATERIAL COMMON NAME (CHAR X(8) IN 1300)
1324* REHEATER STEAM/WATER PRESSURE - PSIG (INTEGER NUMBER 9(5) IN 1300)
1325* REHEATER STEAM/WATER TEMPERATURE - F (INTEGER NUMBER 999 IN 1300)
1326* REHEATER ENERGY REQUIREMENT - MM BTU/HR (INTEGER NUMBER 999 IN 1300)
1400* FANS (RECORD IN 900)
1401* NUMBER OF FANS (INTEGER NUMBER 99 IN 1400)
1402* FAN NUMBER OF SPARES (INTEGER NUMBER 9 IN 1400)
1403* FAN PLACED IN SERVICE - YYMM (INTEGER NUMBER 9999 IN 1400)
1404* FAN REMOVED FROM SERVICE - YYMM (INTEGER NUMBER 9999 IN 1400)
1405* FAN DESIGN - CENTRIFUGAL/AXIAL (CHAR X(8) IN 1400)
1406* FAN SUPPLIER (CHAR X(8) IN 1400)
1407* FAN FUNCTION - UNIT/BOOSTER (CHAR X(8) IN 1400)
1408* FAN APPLICATION WRT FGD SYSTEM - ID/FD (CHAR X(8) IN 1400)

(continued)

TABLE 1 (continued)

```
  1409*  FAN SERVICE - WET/DRY (CHAR X(8) IN 1400)
  1410*  FAN LOCATION WRT MAJOR COMPONENTS (CHAR X(8) IN 1400)
  1411*  FAN FLUE GAS FLOW RATE - ACFM (INTEGER NUMBER 9(9) IN 14
         00)
  1412*  FAN FLUE GAS TEMPERATURE - F (INTEGER NUMBER 9999 IN 140
         0)
  1413*  FAN PRESSURE DROP - IN H2O (DECIMAL NUMBER 99.9 IN 1400)

  1414*  FAN CONSTRUCTION MATERIAL GENERIC TYPE (CHAR X(8) IN 140
         0)
  1415*  FAN CONSTRUCTION MATERIAL SPECIFIC TYPE (CHAR X(8) IN 14
         00)
  1416*  FAN CONSTRUCTION MATERIAL COMMON NAME (CHAR X(8) IN 1400
         )
  1417*  FAN WASH TYPE (CHAR X(8) IN 1400)
1500*  DAMPERS (RECORD IN 900)
  1501*  DAMPER LOCATION (CHAR X(8) IN 1500)
  1502*  NUMBER OF DAMPERS (INTEGER NUMBER 99 IN 1500)
  1503*  DAMPER PLACED IN SERVICE - YYMM (INTEGER NUMBER 9999 IN
         1500)
  1504*  DAMPER REMOVED FROM SERVICE - YYMM (INTEGER NUMBER 9999
         IN 1500)
  1505*  DAMPER FUNCTION - CONTROL/SHUT-OFF (CHAR X(8) IN 1500)
  1506*  DAMPER GENERIC TYPE - LOUVER/BUTTERFLY/ETC (CHAR X(8) IN
          1500)
  1507*  DAMPER SPECIFIC TYPE - OPPOSED BLADE MULTILOUVER/TOP-E N
         TRY GUILLOTINE/ETC (CHAR X(8) IN 1500)
  1508*  DAMPER COMMON DESIGN - SINGLE LOUBER/DOUBLE LOUVER/ETC (
         CHAR X(8) IN 1500)
  1509*  DAMPER MANUFACTURER (CHAR X(8) IN 1500)
  1510*  DAMPER MODULATION - OPEN/CLOSED/ETC (CHAR X(8) IN 1500)
  1511*  DAMPER SEAL AIR ACFM - WHEN APPLICABLE (INTEGER NUMBER 9
         (5) IN 1500)
  1512*  DAMPER SERVICE CONDITIONS - MAX GAS TEMP/TIME (CHAR X(8)
          IN 1500)
  1513*  DAMPER CONSTRUCTION MATERIAL GENERIC TYPE (CHAR X(8) IN
         1500)
  1514*  DAMPER CONSTRUCTION MATERIAL SPECIFIC TYPE (CHAR X(8) IN
          1500)
  1515*  DAMPER CONSTRUCTION MATERIAL COMMON NAME (CHAR X(8) IN 1
         500)
  1516*  DAMPER LINER CONSTRUCTION MATERIAL GENERIC TYPE (CHAR X(
         8) IN 1500)
  1517*  DAMPER LINER CONSTRUCTION MATERIAL SPECIFIC TYPE (CHAR X
         (8) IN 1500)
  1518*  DAMPER LINER CONSTRUCTION MATERIAL COMMON NAME (CHAR X(8
         ) IN 1500)
1600*  DUCTWORK (RECORD IN 900)
  1601*  DUCTWORK LOCATION (CHAR X(8) IN 1600)
  1602*  DUCTWORK CONFIGURATION - CIRCULAR/RECTANGULAR/ETC (CHAR
         X(8) IN 1600)
  1603*  DUCTWORK DIMENSIONS - DIAMETER/LENGTH/ETC (CHAR X(8) IN
         1600)
  1604*  DUCTWORK SHELL CONSTRUCTION MATERIAL GENERIC TYPE (CHAR
         X(8) IN 1600)
```

(continued)

TABLE 1 (continued)

  - 1605* DUCTWORK SHELL CONSTRUCTION MATERIAL SPECIFIC TYPE (CHAR X(8) IN 1600)
  - 1606* DUCTWORK SHELL CONSTRUCTION MATERIAL COMMON NAME (CHAR X(8) IN 1600)
  - 1607* DUCTWORK LINER CONSTRUCTION MATERIAL GENERIC TYPE (CHAR X(8) IN 1600)
  - 1608* DUCTWORK LINER CONSTRUCTION MATERIAL SPECIFIC TYPE (CHAR X(8) IN 1600)
  - 1609* DUCTWORK LINER CONSTRUCTION MATERIAL COMMON NAME (CHAR X(8) IN 1600)
- 1650* EXPANSION JOINTS (RECORD IN 900)
  - 1651* EXPANSION JOINT LOCATION (CHAR X(8) IN 1650)
  - 1652* EXPANSION JOINT TYPE - METALLIC/ELASTOMERIC (CHAR X(8) IN 1650)
  - 1653* EXPANSION JOINT FUNCTION - GAS CIRCUIT/LIQUID CIRCUIT (CHAR X(8) IN 1650)
  - 1654* EXPANSION JOINT PRESSURE - POSITIVE/NEGATIVE (CHAR X(8) IN 1650)
  - 1655* EXPANSION JOINT OPERATING TEMPERATURE - F (INTEGER NUMBER 999 IN 1650)
  - 1656* EXPANSION JOINT DESIGN CONFIGURATION - U-SHAPED/ETC (CHAR X(8) IN 1650)
  - 1657* EXPANSION JOINT MANUFACTURER (CHAR X(8) IN 1650)
  - 1658* EXPANSION JOINT MATERIAL (CHAR X(8) IN 1650)
- 1700* REAGENT PREPARATION EQUIPMENT (RECORD IN 900)
  - 1701* REAGENT PREP EQUIP GENERIC TYPE - WET BALL MILL/SLAKER/ETC (CHAR X(8) IN 1700)
  - 1702* REAGENT PREP EQUIP SPECIFIC TYPE - COMPARTMENTED/DETENTION/ETC (CHAR X(8) IN 1700)
  - 1703* REAGENT PREP EQUIP COMMON DESIGN - 2-COMPARTMENT/AGITATED TANK/ETC (CHAR X(8) IN 1700)
  - 1704* REAGENT PREP DEVICE MANUFACTURER (CHAR X(8) IN 1700)
  - 1705* REAGENT PREP NUMBER OF DEVICES (INTEGER NUMBER 99 IN 1700)
  - 1706* REAGENT PREP NUMBER OF SPARES (INTEGER NUMBER 9 IN 1700)
  - 1707* REAGENT PREP DEVICE PLACED IN SERVICE - YYMM (INTEGER NUMBER 9999 IN 1700)
  - 1708* REAGENT PREP DEVICE REMOVED FROM SERVICE - YYMM (INTEGER NUMBER 9999 IN 1700)
  - 1709* REAGENT PREP DEVICE FULL LOAD DRY FEED CAPACITY - TPH (INTEGER NUMBER 9999 IN 1700)
  - 1710* REAGENT PREP DEVICE PRODUCT QUALITY - % SOLIDS (DECIMAL NUMBER 99.9 IN 1700)
  - 1711* REAGENT PREP FULL LOAD PRODUCT QUANTITY EMPLOYED - GPM (INTEGER NUMBER 9999 IN 1700)
  - 1712* REAGENT PREP POINT OF ADDITION (CHAR X(8) IN 1700)
  - 1713* REAGENT ON-SITE STORAGE CAPACITY - DAYS (INTEGER NUMBER 999 IN 1700)
  - 1714* REAGENT PREP EQUIPMENT MATERIALS (CHAR X(8) IN 1700)
- 1800* TANKS (RECORD IN 900)
  - 1801* TANK-EQUIPMENT/AREA SUPPORTED - ABSORBER/MAKEUP WATER/ETC (CHAR X(8) IN 1800)
  - 1802* NUMBER OF TANKS (INTEGER NUMBER 99 IN 1800)

(continued)

TABLE 1 (continued)

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  1803*  TANK NUMBER OF SPARES (INTEGER NUMBER 9 IN 1800)
  1804*  TANK PLACED IN SERVICE - YYMM (INTEGER NUMBER 9999 IN 18
         00)
  1805*  TANK REMOVED FROM SERVICE - YYMM (INTEGER NUMBER 9999 IN
          1800)
  1806*  TANK FUNCTION - STORAGE/EFFLUENT HOLD/ETC (CHAR X(8) IN
         1800)
  1807*  TANK LOCATION (CHAR X(8) IN 1800)
  1808*  TANK TYPE - OPEN/CLOSED (CHAR X(8) IN 1800)
  1809*  TANK DIMENSIONS - FT (CHAR X(8) IN 1800)
  1810*  TANK CAPACITY - GAL (INTEGER NUMBER 9(7) IN 1800)
  1811*  TANK RETENTION TIME (CHAR X(8) IN 1800)
  1812*  TANK NUMBER OF AGITATORS (INTEGER NUMBER 99 IN 1800)
  1813*  TANK AGITATOR CONFIGURATION (CHAR X(8) IN 1800)
  1814*  TANK AGITATOR MATERIALS OF CONSTRUCTION (CHAR X(8) IN 18
         00)
  1815*  TANK CONSTRUCTION MATERIAL GENERIC TYPE (CHAR X(8) IN 18
         00)
  1816*  TANK CONSTRUCTION MATERIAL SPECIFIC TYPE (CHAR X(8) IN 1
         800)
  1817*  TANK CONSTRUCTION MATERIAL COMMON TYPE (CHAR X(8) IN 180
         0)
  1818*  TANK LINER MATERIAL GENERIC TYPE (CHAR X(8) IN 1800)
  1819*  TANK LINER MATERIAL SPECIFIC TYPE (CHAR X(8) IN 1800)
  1820*  TANK LINER MATERIAL COMMON NAME (CHAR X(8) IN 1800)
1900*  PUMPS (RECORD IN 900)
  1901*  PUMP FUNCTION - ADDITIVE FEED/ABSORBER RECIRCULATION/ETC
          (CHAR X(8) IN 1900)
  1902*  NUMBER OF PUMPS (INTEGER NUMBER 99 IN 1900)
  1903*  PUMP NUMBER OF SPARES (INTEGER NUMBER 9 IN 1900)
  1904*  PUMP PLACED IN SERVICE - YYMM (INTEGER NUMBER 9999 IN 19
         00)
  1905*  PUMP REMOVED FROM SERVICE - YYMM (INTEGER NUMBER 9999 IN
          1900)
  1906*  PUMP GENERIC TYPE - DISPLACEMENT/NONDISPLACEMENT (CHAR X
         (8) IN 1900)
  1907*  PUMP SPECIFIC TYPE - RECIPRUCATING/CENTRIFUGAL/ETC (CHAR
          X(8) IN 1900)
  1908*  PUMP COMMON DESIGN - DIAPHRAGM/SINGLE-ADMISSION INTAKE/E
          TC (CHAR X(8) IN 1900)
  1909*  PUMP MANUFACTURER (CHAR X(8) IN 1900)
  1910*  PUMP MODEL (CHAR X(8) IN 1900)
  1911*  PUMP DRIVE - BELT/VARIABLE/DIRECT/ETC (CHAR X(8) IN 1900
         )
  1912*  PUMP CAPACITY - GPM (INTEGER NUMBER 9(5) IN 1900)
  1913*  PUMP MOTOR BRAKE HP (INTEGER NUMBER 9(5) IN 1900)
  1914*  PUMP SPEED - RPM (INTEGER NUMBER 9(5) IN 1900)
  1915*  PUMP HEAD - FT (DECIMAL NUMBER 999.9 IN 1900)
  1916*  PUMP SERVICE - PH/SOLIDS (CHAR X(8) IN 1900)
  1917*  PUMP CASING CONSTRUCTION MATERIAL GENERIC TYPE (CHAR X(8
         ) IN 1900)
  1918*  PUMP CASING CONSTRUCTION MATERIAL SPECIFIC TYPE (CHAR X(
         8) IN 1900)
  1919*  PUMP CASING CONSTRUCTION MATERIAL COMMON NAME (CHAR X(8)
          IN 1900)
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(continued)

TABLE 1 (continued)

1920*	PUMP IMPELLER CONSTRUCTION MATERIAL GENERIC TYPE (CHAR X(8) IN 1900)
1921*	PUMP IMPELLER CONSTRUCTION MATERIAL SPECIFIC TYPE (CHAR X(8) IN 1900)
1922*	PUMP IMPELLER CONSTRUCTION MATERIAL COMMON NAME (CHAR X(8) IN 1900)
1923*	PUMP LINER CONSTRUCTION MATERIAL GENERIC TYPE (CHAR X(8) IN 1900)
1924*	PUMP LINER CONSTRUCTION MATERIAL SPECIFIC TYPE (CHAR X(8) IN 1900)
1925*	PUMP LINER CONSTRUCTION MATERIAL COMMON NAME (CHAR X(8) IN 1900)
2000*	SOLIDS CONCENTRATING/DEWATERING (RECORD IN 900)
2001*	CONCENTRATING/DEWATERING DEVICE GENERIC TYPE- THICKENER/ VACUUM FILTER/ETC (CHAR X(8) IN 2000)
2002*	CONCENTRATING/DEWATERING DEVICE SPECIFIC TYPE - GRAVITY/ DRUM/ HORIZONTAL BELT/ETC (CHAR X(8) IN 2000)
2003*	CONCENTRATING/DEWATERING DEVICE COMMON DESIGN - TRUSS TYPE/ ROTARY DRUM/BELT FILTER/ETC (CHAR X(8) IN 2000)
2004*	DEVICE FUNCTION - THICKENING/FILTRATION/ETC (CHAR X(8) IN 2000)
2005*	NUMBER OF CONCENTRATING/DEWATERING DEVICES (INTEGER NUMBER 99 IN 2000)
2006*	NUMBER OF SPARE CONCENTRATING/DEWATERING DEVICES (CHAR X(8) IN 2000)
2007*	DEVICE PLACED IN SERVICE - YYMM (INTEGER NUMBER 9999 IN 2000)
2008*	DEVICE REMOVED FROM SERVICE - YYMM (INTEGER NUMBER 9999 IN 2000)
2009*	DEVICE CONFIGURATION (CHAR X(8) IN 2000)
2010*	DEVICE DIMENSIONS - FT (CHAR X(8) IN 2000)
2011*	DEVICE CAPACITY (CHAR X(8) IN 2000)
2012*	DEVICE SHELL CONSTRUCTION MATERIAL GENERIC TYPE (CHAR X(8) IN 2000)
2013*	DEVICE SHELL CONSTRUCTION MATERIAL SPECIFIC TYPE (CHAR X(8) IN 2000)
2014*	DEVICE SHELL CONSTRUCTION MATERIAL COMMON NAME (CHAR X(8) IN 2000)
2015*	DEVICE LINER CONSTRUCTION MATERIAL GENERIC TYPE (CHAR X(8) IN 2000)
2016*	DEVICE LINER CONSTRUCTION MATERIAL SPECIFIC TYPE (CHAR X(8) IN 2000)
2017*	DEVICE LINER CONSTRUCTION MATERIAL COMMON NAME (CHAR X(8) IN 2000)
2018*	DEVICE BELT CONSTRUCTION MATERIAL GENERIC TYPE (CHAR X(8) IN 2000)
2019*	DEVICE BELT CONSTRUCTION MATERIAL SPECIFIC TYPE (CHAR X(8) IN 2000)
2020*	DEVICE BELT CONSTRUCTION MATERIAL COMMON NAME (CHAR X(8) IN 2000)
2021*	DEVICE RAKE MATERIAL (CHAR X(8) IN 2000)
2022*	DEVICE FEED STREAM SOURCE - ABSORBER BLEED/THICKENER UNDERFLOW/ ETC (CHAR X(8) IN 2000)
2023*	DEVICE FEED STREAM CHARACTERISTICS - VOLUME FLOW RATE/% SOLIDS (CHAR X(8) IN 2000)

(continued)

TABLE 1 (continued)

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  2024*  OUTLET STREAM CHARACTERISTICS - VOLUME FLOW RATE/% SOLID
         S (CHAR X(8) IN 2000)
  2025*  OVERFLOW STREAM CHARACTERISTICS - VOLUME FLOW RATE/% SOL
         IDS (CHAR X(8) IN 2000)
  2026*  OUTLET STREAM DISPOSITION (CHAR X(8) IN 2000)
  2027*  OVERFLOW STREAM DISPOSITION (CHAR X(8) IN 2000)
2100*  END PRODUCT (RECORD IN 900)
  2200*  RECOVERABLE BYPRODUCT (RECORD IN 2100)
    2201*  BYPRODUCT NATURE - GYPSUM/ELEMENTAL SULFUR/ETC (CHAR X
           (8) IN 2200)
    2202*  FULL LOAD BYPRODUCT QUANTITY - TPH (DECIMAL NUMBER 99.
           9 IN 2200)
    2203*  BYPRODUCT QUALITY - % (DECIMAL NUMBER 999.9 IN 2200)
    2204*  BYPRODUCT DISPOSITION - ACID PLANT/FERTILIZER PLANT/ET
            C (CHAR X(8) IN 2200)
    2205*  NATURE OF END PRODUCT - SULFUR/SULFURIC ACID/ETC (CHAR
            X(8) IN 2200)
  2300*  SLUDGE (RECORD IN 2100)
    2301*  FULL LOAD SLUDGE QUANTITY - TPH/DRY (DECIMAL NUMBER 99
           .9 IN 2300)
    2302*  SLUDGE MOISTURE CONTENT - % TOTAL FREE WATER (DECIMAL
           NUMBER 99.9 IN 2300)
    2303*  SLUDGE % CASO3 - DRY (DECIMAL NUMBER 99.9 IN 2300)
    2304*  SLUDGE % CASO4 - DRY (DECIMAL NUMBER 99.9 IN 2300)
    2305*  SLUDGE % CAOH2 - DRY (DECIMAL NUMBER 99.9 IN 2300)
    2306*  SLUDGE % CACO3 - DRY (DECIMAL NUMBER 99.9 IN 2300)
    2307*  SLUDGE % ASH - DRY (DECIMAL NUMBER 99.9 IN 2300)
    2308*  SLUDGE % SODIUM COMPOUNDS - DRY (DECIMAL NUMBER 99.9 I
           N 2300)
    2309*  SLUDGE % OTHER COMPOUNDS - DRY (DECIMAL NUMBER 99.9 IN
            2300)
    2400*  PROCESSING (RECORD IN 2300)
      2401*  PROCESSING SPECIFIC TYPE - FIXATION/BLEED/ETC (CHAR
             X(8) IN 2400)
      2402*  PROCESSING COMMON DESIGN - RECYCLE STREAM/BLAST FURN
             ACE SLAG/ FLYASH/ETC (CHAR X(8) IN 2400)
      2403*  PROCESSING TYPE PLACED IN SERVICE - YYMM (INTEGER NU
             MBER 9999 IN 2400)
      2404*  PROCESSING TYPE REMOVED FROM SERVICE - YYMM (INTEGER
              NUMBER 9999 IN 2400)
      2405*  PROCESSING DEVICE - OXIDATION TANK/PUG MILL/ETC (CHA
             R X(8) IN 2400)
      2406*  PROCESSING PROPRIETARY PROCESS - CONV SYSTEMS POZ-O-
              TEC /DRAVO CALCILOX/ETC (CHAR X(8) IN 2400)
      2407*  PROCESSING INLET FLOW RATE - GPM (INTEGER NUMBER 9(5
             ) IN 2400)
      2408*  PROCESSING INLET QUALITY - % SOLIDS (DECIMAL NUMBER
             999.9 IN 2400)
    2500*  DISPOSAL (RECORD IN 2300)
      2501*  NATURE - INTERIM/FINAL (CHAR X(8) IN 2500)
      2502*  DISPOSAL GENERIC TYPE - LANDFILL/POND/ETC (CHAR X(8)
              IN 2500)
      2503*  DISPOSAL SPECIFIC TYPE - DIKED/SIDE HILL/ETC (CHAR X
             (8) IN 2500)
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(continued)

TABLE 1 (continued)

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          2504*  DISPOSAL COMMON DESIGN - ABOVE GRADE/ABANDONED SURFA
                  CE MINE/ETC (CHAR X(8) IN 2500)
          2505*  DISPOSAL LOCATION - ON-SITE/OFF-SITE (CHAR X(8) IN 2
                 500)
          2506*  DISPOSAL SITE TRANSPORTATION METHOD - PIPE LINE/TRUC
                 K /ETC (CHAR X(8) IN 2500)
          2507*  DISPOSAL SITE TREATMENT - CLAY LINING/SYNTHETIC LINI
                  NG/ETC (CHAR X(8) IN 2500)
          2508*  DISPOSAL SITE DIMENSIONS - AREA/DEPTH (CHAR X(8) IN
                 2500)
          2509*  DISPOSAL SITE CAPACITY - VOLUME/ACRE-FT/TONS (DECIMA
                 L NUMBER 9(6).9 IN 2500)
          2510*  DISPOSAL SITE SERVICE LIFE - YRS (INTEGER NUMBER 999
                  IN 2500)
   2600*  PROCESS CONTROL & INSTRUMENTATION (RECORD IN 900)
     2601*  PROCESS STREAM (CHAR X(8) IN 2600)
     2602*  CHEMICAL PARAMETERS - PH/ETC (CHAR X(8) IN 2600)
     2603*  PHYSICAL PARAMETERS - % SOLIDS/FLOW/ETC (CHAR X(8) IN 26
            00)
     2604*  CONTROL LEVELS (CHAR X(8) IN 2600)
     2605*  MONITOR TYPE (CHAR X(8) IN 2600)
     2606*  MONITOR LOCATION (CHAR X(8) IN 2600)
     2607*  PROCESS CONTROL MANNER - AUTOMATIC/MANUAL (CHAR X(8) IN
            2600)
     2608*  PROCESS CHEMISTRY MODE - FEEDBACK/FEED FORWARD (CHAR X(8
            ) IN 2600)
   2700*  WATER BALANCE (RECORD IN 900)
     2701*  WATER BALANCE ENTRIES - DESIGN/ACTUAL (CHAR X(8) IN 2700
            )
     2702*  WATER LOOP TYPE - OPEN/CLOSED (CHAR X(8) IN 2700)
     2703*  EVAPORATION WATER LOSS - GPM (INTEGER NUMBER 9(5) IN 270
            0)
     2704*  SLUDGE HYDRATION WATER LOSS - GPM (INTEGER NUMBER 9(5) I
            N 2700)
     2705*  SLUDGE INTERSTITIAL WATER LOSS - GPM (INTEGER NUMBER 9(5
            ) IN 2700)
     2706*  POND SEEPAGE/RUNOFF WATER LOSS (CHAR X(8) IN 2700)
     2707*  EFFLUENT WATER LOSS - GPM (INTEGER NUMBER 9(5) IN 2700)
     2708*  RECEIVING WATER STREAM NAME (CHAR X(8) IN 2700)
     2709*  MAKEUP WATER ADDITION - GPM (INTEGER NUMBER 9(5) IN 2700
            )
     2710*  SOURCE OF MAKEUP WATER - RIVER WATER/ETC (CHAR X(8) IN 2
            700)
     2711*  MAKEUP WATER ADDITION POINTS & AMOUNTS (CHAR X(8) IN 270
            0)
     2712*  MAKEUP WATER PRE-TREATMENT TYPE (CHAR X(8) IN 2700)
   2800*  CHEMICALS & CONSUMPTION (RECORD IN 900)
     2801*  CHEMICAL FUNCTION - ABSORBENT/SOLIDS SETTLING/ETC (CHAR
            X(8) IN 2800)
     2802*  CHEMICAL NAME - LIMESTONE/ADIPIC ACID/ETC (CHAR X(8) IN
            2800)
     2803*  CHEMICAL PRINCIPAL CONSTITUENT (CHAR X(8) IN 2800)
     2804*  CHEMICAL SOURCE/SUPPLIER (CHAR X(8) IN 2800)
     2805*  CHEMICAL SUPPLIER LOCATION (CHAR X(8) IN 2800)
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(continued)

TABLE 1 (continued)

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    2806*  CHEMICAL CONSUMPTION - SPECIFY TPY/TPH/ETC (CHAR X(8) IN
            2800)
    2807*  CHEMICAL UTILIZATION - % (DECIMAL NUMBER 999.9 IN 2800)
    2808*  CHEMICAL POINT OF ADDITION (CHAR X(8) IN 2800)
  2900*  MAJOR PIPING & VALVES (RECORD IN 900)
    2901*  PIPE/VALVE (CHAR X(8) IN 2900)
    2902*  PIPE/VALVE LOCATION (CHAR X(8) IN 2900)
    2903*  PIPE/VALVE FUNCTION - INSTRUMENT AIR/SERVICE WATER/ETC (
           CHAR X(8) IN 2900)
    2904*  PIPE/VALVE GENERIC TYPE - BALL/GATE/GLOBE/ETC (CHAR X(8)
            IN 2900)
    2905*  PIPE/VALVE SPECIFIC TYPE - FREE BALL/WEDGE/ETC (CHAR X(8
           ) IN 2900)
    2906*  PIPE/VALVE DIMENSIONS - IN (CHAR X(8) IN 2900)
    2907*  PIPE/VALVE MANUFACTURER (CHAR X(8) IN 2900)
    2908*  PIPE/VALVE SHELL CONSTRUCTION MATERIAL GENERIC TYPE (CHA
           R X(8) IN 2900)
    2909*  PIPE/VALVE SHELL CONSTRUCTION MATERIAL SPECIFIC TYPE (CH
           AR X(8) IN 2900)
    2910*  PIPE/VALVE SHELL CONSTRUCTION MATERIAL COMMON NAME (CHAR
            X(8) IN 2900)
    2911*  PIPE/VALVE LINER CONSTRUCTION MATERIAL GENERIC TYPE (CHA
           R X(8) IN 2900)
    2912*  PIPE/VALVE LINER CONSTRUCTION MATERIAL SPECIFIC TYPE (CH
           AR X(8) IN 2900)
    2913*  PIPE/VALVE LINER CONSTRUCTION MATERIAL COMMON NAME (CHAR
            X(8) IN 2900)
3000*  FGD SPARE CAPACITY INDICES (RECORD IN 800)
  3001*  SCRUBBER SPARE CAPACITY - % (DECIMAL NUMBER 999.9 IN 3000)

  3002*  ABSORBER SPARE CAPACITY - % (DECIMAL NUMBER 999.9 IN 3000)

  3003*  MIST ELIMINATOR SPARE CAPACITY - % (DECIMAL NUMBER 999.9 I
         N 3000)
  3004*  REHEATER SPARE CAPACITY - % (DECIMAL NUMBER 999.9 IN 3000)

  3005*  FAN SPARE CAPACITY - % (DECIMAL NUMBER 999.9 IN 3000)
  3006*  BALL MILL SPARE CAPACITY - % (DECIMAL NUMBER 999.9 IN 3000
         )
  3007*  SLAKER SPARE CAPACITY - % (DECIMAL NUMBER 999.9 IN 3000)
  3008*  EFFLUENT HOLD TANK SPARE CAPACITY - % (DECIMAL NUMBER 999.
         9 IN 3000)
  3009*  RECIRCULATION PUMP SPARE CAPACITY - % (DECIMAL NUMBER 999.
         9 IN 3000)
  3010*  THICKENER SPARE CAPACITY - % (DECIMAL NUMBER 999.9 IN 3000
         )
  3011*  VACUUM FILTER SPARE CAPACITY - % (DECIMAL NUMBER 999.9 IN
         3000)
  3012*  CENTRIFUGE SPARE CAPACITY - % (DECIMAL NUMBER 999.9 IN 300
         0)
3100*  FGD SPARE COMPONENT INDICES (RECORD IN 800)
  3101*  SCRUBBER SPARE COMPONENT INDEX (DECIMAL NUMBER 999.9 IN 31
         00)
  3102*  ABSORBER SPARE COMPONENT INDEX (DECIMAL NUMBER 999.9 IN 31
         00)
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(continued)

TABLE 1 (continued)

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     3103*  MIST ELIMINATOR SPARE COMPONENT INDEX (DECIMAL NUMBER 999.
            9 IN 3100)
     3104*  REHEATER SPARE COMPONENT INDEX (DECIMAL NUMBER 999.9 IN 31
            00)
     3105*  FAN SPARE COMPONENT INDEX (DECIMAL NUMBER 999.9 IN 3100)
     3106*  BALL MILL SPARE COMPONENT INDEX (DECIMAL NUMBER 999.9 IN 3
            100)
     3107*  SLAKER SPARE COMPONENT INDEX (DECIMAL NUMBER 999.9 IN 3100
            )
     3108*  EFFLUENT HOLD TANK SPARE COMPONENT INDEX (DECIMAL NUMBER 9
            99.9 IN 3100)
     3109*  RECIRCULATION PUMP SPARE COMPONENT INDEX (DECIMAL NUMBER 9
            99.9 IN 3100)
     3110*  THICKENER SPARE COMPONENT INDEX (DECIMAL NUMBER 999.9 IN 3
            100)
     3111*  VACUUM FILTER SPARE COMPONENT INDEX (DECIMAL NUMBER 999.9
            IN 3100)
     3112*  CENTRIFUGE SPARE COMPONENT INDEX (DECIMAL NUMBER 999.9 IN
            3100)
   3200*  PILOT PLANT (RECORD IN 800)
     3201*  PILOT PLANT UNIT NUMBER (CHAR X(8) IN 3200)
     3202*  PILOT PLANT PARTICIPANTS (CHAR X(8) IN 3200)
     3203*  PILOT PLANT PROCESS (CHAR X(8) IN 3200)
     3204*  PILOT PLANT DESIGN (CHAR X(8) IN 3200)
     3205*  PILOT PLANT SUPPLIER (CHAR X(8) IN 3200)
     3206*  PILOT PLANT SERVICE DATE - YYMM (INTEGER NUMBER 9999 IN 32
            00)
     3207*  PILOT PLANT PERIOD OF OPERATION - MONTHS (INTEGER NUMBER 9
            99 IN 3200)
     3208*  PILOT PLANT GAS FEED (CHAR X(8) IN 3200)
     3209*  PILOT PLANT EQUIVALENT SCRUBBED CAPACITY - MW (DECIMAL NUM
            BER 999.999 IN 3200)
     3210*  PILOT PLANT STATUS - ACTIVE/TERMINATED (CHAR X(8) IN 3200)

   3300*  FGD ECONOMICS (RECORD IN 800)
     3301*  ECONOMICS TYPE - REPORTED/ADJUSTED/STANDARDIZED (CHAR X(8)
             IN 3300)
     3302*  DIRECT CAPITAL COST - $ (MONEY $9(9).99 IN 3300)
     3303*  INDIRECT CAPITAL COST - $ (MONEY $9(9).99 IN 3300)
     3304*  OTHER CAPITAL CHARGES - $ (MONEY $9(9).99 IN 3300)
     3305*  CAPITAL COST YEAR (INTEGER NUMBER 9999 IN 3300)
     3306*  TOTAL CAPITAL COST - $ (MONEY $9(9).99 IN 3300)
     3307*  TOTAL $/KW (MONEY $9999.9 IN 3300)
     3308*  DIRECT ANNUAL COST - $ (MONEY $9(9).99 IN 3300)
     3309*  OVERHEAD COST - $ (MONEY $9(9).99 IN 3300)
     3310*  FIXED CHARGES - $ (MONEY $9(9).99 IN 3300)
     3311*  TOTAL ANNUAL COST - $ (MONEY $9(9).99 IN 3300)
     3312*  ANNUAL COST YEAR (INTEGER NUMBER 9999 IN 3300)
     3313*  TOTAL MILLS/KWH (DECIMAL NUMBER 999.99 IN 3300)
     3314*  CAPACITY FACTOR - % (INTEGER NUMBER 999 IN 3300)
 3400*  SYSTEM DEPENDABILITY PERFORMANCE (RECORD)
   3401*  PERFORMANCE DATE - YYMM (INTEGER NUMBER 9999 IN 3400)
   3402*  PERIOD - HR (INTEGER NUMBER 9999 IN 3400)
   3403*  BOILER - HR (INTEGER NUMBER 9999 IN 3400)
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(continued)

TABLE 1 (continued)

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3404*  UNIT CAPACITY FACTOR - % (DECIMAL NUMBER 999.9 IN 3400)
3405*  UNIT AVAILABILITY - % (DECIMAL NUMBER 999.9 IN 3400)
3410*  LOST GENERATION FACTOR - % (DECIMAL NUMBER 999.9 IN 3400)
3411*  MEGAWATT-HOURS GENERATED (INTEGER NUMBER 9(7) IN 3400)
3412*  PERFORMANCE LOAD DATE - YYMM (INTEGER NUMBER 9999 IN 3400)
3440*  SYSTEM MODULE PERFORMANCE (RECORD IN 3400)
  3441*  MODULE PERFORMANCE DATE - YYMM (INTEGER NUMBER 9999 IN 344
         0)
  3443*  MODULE NUMBER (CHAR X(8) IN 3440)
  3444*  SERVICE - HR (INTEGER NUMBER 9999 IN 3440)
  3445*  FORCED OUTAGE TIME - HR (INTEGER NUMBER 9999 IN 3440)
  3446*  SCHEDULED OUTAGE TIME - HR (INTEGER NUMBER 9999 IN 3440)
  3447*  MODULE AVAILABILITY - % (DECIMAL NUMBER 999.9 IN 3440)
  3448*  MODULE OPERABILITY - % (DECIMAL NUMBER 999.9 IN 3440)
  3449*  MODULE RELIABILITY - % (DECIMAL NUMBER 999.9 IN 3440)
  3450*  MODULE UTILIZATION - % (DECIMAL NUMBER 999.9 IN 3440)
  3451*  MODULE AVAILABLE TIME - HR (INTEGER NUMBER 9999 IN 3440)
3460*  PROBLEMS/SOLUTIONS/COMMENTS (RECORD IN 3400)
  3461*  PROBLEM START DATE - YYMM (INTEGER NUMBER 9999 IN 3460)
  3462*  PROBLEM END DATE - YYMM (INTEGER NUMBER 9999 IN 3460)
  3463*  EQUIPMENT CODE (CHAR X(8) IN 3460)
  3464*  PROBLEM CLASS CODE (CHAR X(8) IN 3460)
  3465*  PROBLEM TYPE CODE (CHAR X(8) IN 3460)
  3470*  SOLUTION/DESCRIPTION (RECORD IN 3460)
    3471*  SOLUTION/DESCRIPTION SEQUENCE NUMBER (INTEGER NUMBER 99
           IN 3470)
    3472*  SOLUTION/DESCRIPTION NAME (TEXT X(8) IN 3470)
  3480*  PROBLEM MODULE (RECORD IN 3460)
    3481*  PROBLEM MODULE NUMBER (CHAR X(8) IN 3480)
3900*  REMOVAL PERFORMANCE DATA (RECORD)
  3901*  REMOVAL PERFORMANCE DATE - YYMMDD (INTEGER NUMBER 9(6) IN 39
         00)
  3902*  REMOVAL PERFORMANCE DURATION (CHAR X(8) IN 3900)
  3903*  PERFORMANCE MODULE NUMBER (CHAR X(8) IN 3900)
  3904*  PERFORMANCE TESTING ORGANIZATION (CHAR X(8) IN 3900)
  3905*  AVERAGE BOILER LOAD DURING TESTING - NET MW (CHAR X(8) IN 39
         00)
  3906*  SO2 INLET CONCENTRATION - LB/HR (DECIMAL NUMBER 9(5).999 IN
         3900)
  3907*  SO2 INLET CONCENTRATION - PPM-DRY (DECIMAL NUMBER 9999.999 I
         N 3900)
  3908*  SO2 INLET CONCENTRATION - LB/MM BTU (DECIMAL NUMBER 999.999
         IN 3900)
  3909*  SO2 OUTLET CONCENTRATION - LB/HR (DECIMAL NUMBER 999.999 IN
         3900)
  3910*  SO2 OUTLET CONCENTRATION - PPM-DRY (DECIMAL NUMBER 9999.999
         IN 3900)
  3911*  SO2 OUTLET CONCENTRATION - LB/MM BTU (DECIMAL NUMBER 999.999
          IN 3900)
  3912*  % SO2 REMOVAL (DECIMAL NUMBER 999.9 IN 3900)
  3913*  SO2 ANALYSIS METHOD (CHAR X(8) IN 3900)
  3914*  SO2 INLET POINT OF MEASUREMENT (CHAR X(8) IN 3900)
  3915*  SO2 OUTLET POINT OF MEASUREMENT (CHAR X(8) IN 3900)
  3916*  INSTRUMENT CERTIFICATION (CHAR X(8) IN 3900)
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(continued)

TABLE 1 (continued)

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 3917*  PART INLET CONCENTRATION - LB/HR (DECIMAL NUMBER 9(5).999 IN
         3900)
 3918*  PART INLET CONCENTRATION - GR/SCF-DRY (DECIMAL NUMBER 99.999
         IN 3900)
 3919*  PART INLET CONCENTRATION - LB/MM BTU (DECIMAL NUMBER 9(5).99
        9 IN 3900)
 3920*  PART OUTLET CONCENTRATION - LB/HR (DECIMAL NUMBER 999.999 IN
         3900)
 3921*  PART OUTLET CONCENTRATION - GR/SCF-DRY (DECIMAL NUMBER 99.99
        9 IN 3900)
 3922*  PART OUTLET CONCENTRATION - LB/MM BTU (DECIMAL NUMBER 9(5).9
        99 IN 3900)
 3923*  % PART REMOVAL (DECIMAL NUMBER 999.99 IN 3900)
 3924*  PART ANALYSIS METHOD (CHAR X(8) IN 3900)
 3925*  PART INLET POINT OF MEASUREMENT (CHAR X(8) IN 3900)
 3926*  PART OUTLET POINT OF MEASUREMENT (CHAR X(8) IN 3900)
 3927*  PART INSTRUMENT CERTIFICATION (CHAR X(8) IN 3900)
 3928*  OPACITY - % (DECIMAL NUMBER 999.99 IN 3900)
 3929*  NOX INLET CONCENTRATION - LB/HR (DECIMAL NUMBER 9(5).999 IN
        3900)
 3930*  NOX INLET CONCENTRATION - PPM-DRY (DECIMAL NUMBER 9999.999 I
        N 3900)
 3931*  NOX INLET CONCENTRATION -LB/MM BTU (DECIMAL NUMBER 999.999 I
        N 3900)
 3932*  NOX OUTLET CONCENTRATION - LB/HR (DECIMAL NUMBER 999.999 IN
        3900)
 3933*  NOX OUTLET CONCENTRATION - PPM-DRY (DECIMAL NUMBER 9999.999
        IN 3900)
 3934*  NOX OUTLET CONCENTRATION - LB/MM BTU (DECIMAL NUMBER 999.999
         IN 3900)
 3935*  % NOX REMOVAL (DECIMAL NUMBER 999.99 IN 3900)
 3936*  NOX ANALYSIS METHOD (CHAR X(8) IN 3900)
 3937*  NOX INLET POINT OF MEASUREMENT (CHAR X(8) IN 3900)
 3938*  NOX OUTLET POINT OF MEASUREMENT (CHAR X(8) IN 3900)
 3939*  NOX INSTRUMENT CERTIFICATION (CHAR X(8) IN 3900)
4000*  FOOTNOTE - ABSTRACT INFORMATION (RECORD)
 4001*  LITERAL CODE (INTEGER NUMBER 9999 IN 4000)
 4002*  LITERAL DATE - YYMM (INTEGER NUMBER 9999 IN 4000)
 4003*  LITERAL SEQUENCE NUMBER (INTEGER NUMBER 9999 IN 4000)
 4004*  LITERAL DATA (TEXT X(8) IN 4000)
 4005*  LITERAL DATA FIELD NUMBER (INTEGER NUMBER 9999 IN 4000)
```

SECTION 3

DATA BASE EXECUTION

3.1 NCC ACCESS

Before accessing the data base, users must complete an application form (Appendix F) from the National Technical Information Service (NTIS), who will issue an account number for on-line computer access to the EPA National Computer Center (NCC) in Research Triangle Park, North Carolina. The user will also be issued a user ID and password. Additional information regarding NCC access is available through Mr. Wally Finch of NTIS at (703) 487-4807 or Mr. Norman Kaplan of EPA at (919) 541-2556.

The next step in the accessing process is to log into the Univac system at NCC. This requires a telephone and coupler modem, unless one is using a terminal that is wired directly to the system (e.g., the onsite terminals at the NCC center). The terminal also must be compatible with the Univac 1100 system. Any terminal, hard copy or cathode ray tube (CRT), that emulates a Teletype at 30 or 120 bits per second can be supported. The terminal, however, must use the ASCII character set and be set in the half-duplex mode.

The following is a partial listing of known compatible terminals:

DCT 500
Anderson Jacobsen 63x, 83x
Hazeltine 1000, 2000 (CRT)
Hewlett-Packard 2622A
Tektronix 401x, 4051
Teletype 33, 35, 37, 38 (ASR/KSR)
Texas Instrument 7xx, 770/2

These are not the only compatible terminals available, nor does this list represent recommended terminals. More than 100 manufacturers produce hard-copy and CRT terminals, and as long as a terminal can emulate a teletype, it can be supported. DCT 1000's and Uniscope 100's can only be supported over dedicated circuits in synchronous mode.

Access to the NCC system is available to both 300-baud and 1200-baud users through a nationwide telephone communications system (TYMNET) that offers local dial numbers in more than 100 cities, as well as through the WATS service to those for which local numbers are not available. Table 2 presents a complete listing of the available numbers. Users who must use the WATS numbers are requested to call NCC Communication Control [(919) 541-4506] so that candidates for local dial numbers can be identified.

All telecommunication problems (e.g., busy signals, ring-no-answer, line drops) should be reported to NCC Communication Control at (919) 541-4506 or FTS 629-4506. Appendix C provides a complete listing of TYMNET diagnostic messages that may be encountered and their meaning.

Users of the NCC facilities who need assistance (e.g., general assistance, consultation, problem diagnosis) should call the NCC Users Services Support group at (919) 541- 3107 or FTS 629- 3107 between 8:00 a.m. and 4:30 p.m. (Eastern Time), Monday through Friday. Information on the availability of the Univac system can be obtained by calling (919) 541-2226 (2227) or FTS 629-2226 (2227) to access a system status recording that the NCC staff maintains. Actual charges for the on-line access depend on the type of retrieval commands used. A simple command to print a report may cost only $10, whereas a more sophisticated statistical analysis of the data base may cost $150. Users are charged only for the computer resources used, not actual on-line computer connect time (see Appendix G). There is no charge for obtaining an account number.

3.1.1 Computer Log-On

The general log-on procedure to initiate a session on the Univac is as follows:

(1) Turn on the power to the terminal and the acoustic coupler (if the terminal being used has an internal modem, e.g., Teletype Model 43, an acoustic coupler will not be necessary).

(2) Dial the TYMNET telephone number available in your area.

(3) After the telephone has run at least once, listen for a high-pitched tone, which indicates that the proper connection to the communications network has been made.

(4) Upon hearing the tone, couple the terminal to the telephone line by placing the phone handset firmly into the acoustic coupler and

TABLE 2. NCC ACCESS TELEPHONE NUMBERS

City	State	Telephone No.	Modem
Birmingham	Alabama	205/942-4141	(VADIC 3467)
Huntsville	Alabama	205/882-3003	(VADIC 3467)
Mobile	Alabama	205/432-3382	(VADIC 3467)
Montgomery	Alabama	205/834-3410	(VADIC 3467)
Anchorage	Alaska	907/278-3511	(VADIC 3467)
Juneau	Alaska	907/586-6611	(VADIC 3467)
Phoenix	Arizona	602/254-5811	(VADIC 3467)
Tucson	Arizona	602/790-0764	(VADIC 3467)
Fort Smith	Arkansas	501/782-3210	(VADIC 3467)
Jonesboro	Arkansas	501/932-6886	(212A)
Little Rock	Arkansas	501/372-5780	
Little Rock	Arkansas	501/376-3768	(212A)
Springdale	Arkansas	501/756-2201	(VADIC 3467)
Alhambra	California	213/572-0999	
Alhambra	California	213/280-1103	(VADIC 3476)
Antioch	California	415/778-3420	(VADIC 3467)
Arcadia	California	213/574-7636	
Arcadia	California	213/574-8834	(VADIC 3467)
Bakersfield	California	805/324/2653	(VADIC 3467)
Beverly Hills	California	213/203-9865	(VADIC 3467)
Burlingame	California	415/583-6950	(212A)
Canoga Park	California	213/998-3331	(VADIC 3467)
El Segundo	California	213/640-1281	(212A)
Fremont	California	415/490-7366	(VADIC 3467)
Fresno	California	209/268-1211	(VADIC 3467)
Hayward	California	415/785-3431	(VADIC 3467)
Long Beach	California	213/435-7088	(VADIC 3467)
Los Angeles	California	213/626-2400	(212A)
Los Angeles	California	213/626-3030	(212A)
Los Angeles	California	213/623-8500	(1200 VADIC)
Los Angeles	California	213/629-3001	(1200 202S)
Los Angeles	California	213/484-0818	(212A)
Mar Vista	California	213/306-4728	(212A)
Mar Vista	California	213/821-2257	(212A)
Marina Del Rey	California	213/821-2257	(212A)
Mission Hills	California	213/365-2013	
Mission Hills	California	213/365-9277	(212A)
Modesto	California	209/577-5602	(VADIC 3467)
Mt. View/Palo Alto	California	415/941-8450	(212A)
Newport Beach	California	714/662-0490	(VADIC 3467)
Northridge	California	213/998-0461	(VADIC 3467)
Northridge	California	213/998-4872	(212A)
Norwalk	California	213/865-0555	(VADIC 3467)
Norwalk	California	213/865-2066	(212A)
Oakland	California	415/836-8700	(VADIC 3467)
Palm Springs	California	619/320-0772	(VADIC 3467)
Palo Alto/Mt. View	California	415/966-8550	(VADIC 3467)
Pasadena	California	213/577-8696	(VADIC 3467)

(Continued)

TABLE 2 (continued)

City	State	Telephone No.	Modem
Pasadena	California	213/577-8722	(212A)
Pleasant Hill	California	415/798-2093	(VADIC 3467)
Pleasanton	California	415/462-8900	(VADIC 3467)
Rancho Bernardo	California	619/485-1990	(VADIC 3467)
Riverside/Colton	California	714/370-1200	(VADIC 3467)
Sacramento	California	916/448-8151	(VADIC 3467)
Salinas	California	408/443-4333	(VADIC 3467)
San Clemente	California	714/498-3130	(VADIC 3467)
San Diego	California	619/296-3370	(VADIC 3467)
San Fernando	California	213/365-2013	
San Fernando	California	213/365-9277	(212A)
San Francisco	California	415/986-8200	
San Francisco	California	415/788-7955	(212A)
San Francisco	California	415/397-4300	(1200 VADIC)
San Jose/Cupertino	California	408/980-8100	(VADIC 3467)
San Jose/Cupertino	California	408/446-6932	(1200 202S)
San Jose/Cupertino	California	408/257-0593	(CCITT)
San Pedro	California	213/518-3773	(VADIC 3467)
San Pedro	California	213/830-0775	(212A)
Santa Ana	California	714/662-0490	(VADIC 3467)
Santa Barbara	California	805/682-9641	(VADIC 3467)
Santa Cruz	California	408/426-8400	(VADIC 3467)
Santa Monica	California	213/306-4728	(212A)
Santa Rosa	California	707/575-0160	(VADIC 3467)
Van Nuys	California	213/986-9503	
Van Nuys	California	213/906-8450	(VADIC 3467)
Ventura/Oxnard	California	805/486-4811	(VADIC 3467)
Vista	California	619/727-6011	(VADIC 3467)
Walnut Creek	California	415/932-0116	(VADIC 3467)
West Covina	California	213/331-3954	
West Covina	California	213/915-5702	(212A)
Colorado Springs	Colorado	303/475-2121	(VADIC 3467)
Denver	Colorado	303/830-9210	(VADIC 3467)
Bridgeport	Connecticut	203/367-6021	(VADIC 3467)
Danbury	Connecticut	203/748-5061	(VADIC 3467)
Darien	Connecticut	203/965-0000	(VADIC 3467)
Hartford	Connecticut	203/242-7140	(VADIC 3467)
Meriden	Connecticut	203/237-5476	(VADIC 3467)
New Haven	Connecticut	203/789-0579	(VADIC 3467)
New London	Connecticut	203/444-1709	(VADIC 3467)
Steamford	Connecticut	203/965-0000	(VADIC 3467)
Waterbury	Connecticut	203/755-1153	(VADIC 3467)
Westport	Connecticut	203/227-7189	(VADIC 3467)
Washington	District of Columbia	703/442-3900	
Washington	District of Columbia	703/734-3900	
Washington	District of Columbia	703/442-7800	(212A)
Washington	District of Columbia	703/734-8370	(212A)
Washington	District of Columbia	703/442-3960	(VADIC 3467)

(Continued)

TABLE 2 (continued)

City	State	Telephone No.	Modem
Washington	District of Columbia	703/691-8200	(VADIC 3467)
Dover	Delaware	302/678-0449	(VADIC 3467)
Wilmington	Delaware	302/429-0112	(VADIC 3467)
Daytona Beach	Florida	904/252/4481	
Fort Lauderdale	Florida	305/467-3807	(VADIC 3467)
Gainseville	Florida	904/376-0939	(VADIC 3467)
Jacksonville	Florida	904/721-8100	(VADIC 3467)
Melbourne	Florida	305/725-8011	
Melbourne	Florida	305/724-9972	(212A)
Miami	Florida	305/624-7900	(VADIC 3467)
Orlando	Florida	305/851-3530	
Orlando	Florida	305/859-7670	(212A)
Pensacola	Florida	904/434-0134	(VADIC 3467)
Sarasota	Florida	813/365-3526	(212A)
St. Petersburg	Florida	813/535-6441	
St. Petersburg	Florida	813/535-1446	(212A)
Tallahassee	Florida	904/878-6780	(VADIC 3467)
Tampa	Florida	813/977-2400	(212A)
West Palm Beach	Florida	305/627-5410	(VADIC 3467)
Atlanta	Georgia	404/659-1600	(212A)
Savannah	Georgia	912/236-1904	(VADIC 3467)
Savannah	Georgia	912/352-7248	(VADIC 3467)
Honolulu	Hawaii	808/524-8450	(212A)
Boise	Idaho	208/343-0404	(VADIC 3467)
Champaign	Illinois	217/356-7552	(VADIC 3467)
Chicago	Illinois	312/346-4961	
Chicago	Illinois	312/368-4607	
Chicago	Illinois	312/368-4700	
Chicago	Illinois	312/641-1630	(212A)
Chicago	Illinois	312/372-0391	(1200 VADIC)
Chicago	Illinois	312/368-0022	(1200 202S)
Freeport	Illinois	815/233-5585	
Glen Ellyn	Illinois	312/790-4400	(VADIC 3467)
Joliet	Illinois	815/723-9854	(212A)
Lake Zurick	Illinois	312/438-5003	
Peoria	Illinois	309/673-2156	
Rock Island	Illinois	309/794-0731	(VADIC 3467)
Rockford	Illinois	815/398-6090	
Springfield	Illinois	217/753-7905	(VADIC 3467)
Urbana	Illinois	217/356-7552	(VADIC 3467)
Evansville	Indiana	812/425-5211	(VADIC 3467)
Fort Wayne	Indiana	219/424-5162	
Highland	Indiana	219/836-5452	
Indianapolis	Indiana	317/257-3461	(212A)
Marion	Indiana	317/662-0091	
Merrillville	Indiana	219/769-7254	
South Bend	Indiana	219/233-4163	
Cedar Rapids	Iowa	319/363-2482	(VADIC 3467)

(Continued)

TABLE 2 (continued)

City	State	Telephone No.	Modem
Davenport	Iowa	319/324-7197	(VADIC 3467)
Des Moines	Iowa	515/277-7752	(VADIC 3467)
Dubuque	Iowa	319/556-8263	(VADIC 3467)
Iowa City	Iowa	319/354-7371	(VADIC 3467)
Marshalltown	Iowa	515/753-0667	(VADIC 3467)
Waterloo	Iowa	319/233-9227	(VADIC 3467)
Shawnee Mission	Kansas	913/384-1544	(VADIC 3467)
Topeka	Kansas	913/233-1682	(VADIC 3467)
Wichita	Kansas	316/265-1241	(VADIC 3467)
Lexington	Kentucky	606/253-3463	
Lexington	Kentucky	606/253-3498	(212A)
Louisville	Kentucky	502/499-7110	(VADIC 3467)
Bowling Green	Kentucky	502/782-0436	(VADIC 3467)
Baton Rouge	Louisiana	504/291-2650	(VADIC 3467)
Lafayette	Louisiana	318/237-9500	(VADIC 3467)
New Orleans	Louisiana	504/524-4371	(VADIC 3467)
Shreveport	Louisiana	318/688-4666	(VADIC 3467)
Portland	Maine	207/774-2654	(VADIC 3467)
Baltimore	Maryland	301/547-8100	(VADIC 3467)
Myersville	Maryland	301/293/1072	(VADIC 3467)
Rockville	Maryland	301/770-1680	
Bedford	Massachusetts	617/996-8596	(VADIC 3467)
Boston	Massachusetts	617/482-4677	
Boston	Massachusetts	617/482-5605	
Boston	Massachusetts	617/482-7035	(VADIC 3467)
Boston	Massachusetts	617/482-2170	(1200 202S)
Springfield	Massachusetts	413/781-6830	(VADIC 3467)
Worcester	Massachusetts	617/755-0916	(VADIC 3467)
Ann Arbor	Michigan	313/665-2627	
Ann Arbor	Michigan	313/662-8282	(212A)
Cadillac	Michigan	616/775-1261	(VADIC 3467)
Detroit	Michigan	313/963-3388	
Detroit	Michigan	313/963-8880	(212A)
Detroit	Michigan	313/963-2353	(1200 VADIC)
Detroit	Michigan	313/963-4676	(1200 202S)
Flint	Michigan	313/732-7303	(212A)
Grand Rapids	Michigan	616/459-5069	(VADIC 3467)
Jackson	Michigan	517/787-9461	
Kalamazoo	Michigan	616/385-3150	(VADIC 3467)
Lansing	Michigan	517/487-2040	(VADIC 3467)
Manistee	Michigan	616/723-8373	(VADIC 3467)
Midland	Michigan	517/631-4721	(VADIC 3467)
Plymouth	Michigan	313/459-8900	(VADIC 3467)
Saginaw	Michigan	517/753-9921	(VADIC 3467)
Southfield	Michigan	313/569-8350	
St. Joseph	Michigan	616/429-2568	(VADIC 3467)
Traverse City	Michigan	616/946-0002	(VADIC 3467)
Mankato	Minnesota	507/625-1684	(212A)

(Continued)

TABLE 2 (continued)

City	State	Telephone No.	Modem
Minneapolis	Minnesota	612/339-5200	
Minneapolis	Minnesota	612/339-2415	(212A)
Rochester	Minnesota	507/282-3741	
Jackson	Mississippi	601/944-0860	(VADIC 3467)
Pascagoula	Mississippi	601/769-6502	
Pascagoula	Mississippi	601/769-6673	(212A)
Bridgeton	Missouri	314/731-2304	
Columbia	Missouri	314/875-1290	(VADIC 3467)
Jefferson City	Missouri	314/634-3273	(212A)
Joplin	Missouri	417/782-3037	(VADIC 3467)
Kansas City	Missouri	913/384-1544	(VADIC 3467)
Springfield	Missouri	417/831-5044	(VADIC 3467)
St. Joseph	Missouri	816/232-1897	(VADIC 3467)
St. Louis	Missouri	314/421-5110	
St. Louis	Missouri	314/621-4660	(212A)
Butte	Montana	406/494-4637	(VADIC 3467)
Lincoln	Nebraska	402/475-8659	(VADIC 3467)
Omaha	Nebraska	402/397-0414	(VADIC 3467)
Las Vegas	Nevada	702/293-0300	(VADIC 3467)
Reno/Carson City	Nevada	702/882-7810	(VADIC 3467)
Manchester	New Hampshire	603/623-8855	(VADIC 3467)
Nashua	New Hampshire	603/882-0435	(VADIC 3467)
Salem	New Hampshire	603/893-6200	(VADIC 3467)
Cherry Hill	New Jersey	609/665-4613	(VADIC 3467)
Englewood Cliffs	New Jersey	201/894-8250	(VADIC 3467)
Jersey City	New Jersey	201/432-4907	(VADIC 3467)
Lyndhurst	New Jersey	201/460-0100	
Lyndhurst	New Jersey	201/460-0180	(212A)
Moorestown	New Jersey	609/235-3761	
Morristown	New Jersey	201/539-4050	(212A)
New Brunswick	New Jersey	609/452-1018	(VADIC 3467)
Newark/Union	New Jersey	201/483-5937	
Newark/Union	New Jersey	201/483-4878	(212A)
Piscataway	New Jersey	201/981-1900	(VADIC 3467)
Princeton	New Jersey	609/452-1018	(VADIC 3467)
Ridgewood	New Jersey	201/445-8346	(VADIC 3467)
Wayne	New Jersey	201/785-4480	
Albuquerque	New Mexico	505/843-6301	(VADIC 3467)
Albany	New York	518/463-3111	(VADIC 3467)
Binghampton	New York	607/772-1153	(VADIC 3467)
Buffalo	New York	716/845-6610	
Buffalo	New York	716/847-0500	(212A)
Corning	New York	607/962-4481	(VADIC 3467)
Elmira	New York	607/737-9010	(212A)
Hempstead, Long Island	New York	516/872-6500	(VADIC 3467)
Huntington, Long Island	New York	516/549-2780	(VADIC 3467)
Ithica	New York	607/257-6601	(VADIC 3467)
Mineola	New York	516/222-1423	(212A)

(Continued)

TABLE 2 (continued)

City	State	Telephone No.	Modem
New York	New York	212/532-0437	
New York	New York	212/685-4414	
New York	New York	212/269-9642	(VADIC 3467)
New York	New York	212/785-5400	(VADIC 3467)
New York	New York	212/689-8850	(1200 202S)
Niagara Falls	New York	716/285-6691	
Niagara Falls	New York	716/285-3114	(212A)
Poughkeepsie	New York	914/471-6100	(VADIC 3467)
Rochester	New York	716/248-8000	(VADIC 3467)
Syracuse	New York	315/437-7111	(VADIC 3467)
Utica	New York	315/735-2291	(VADIC 3467)
White Plains	New York	914/328-9580	(VADIC 3467)
White Plains	New York	914/684-6075	(VADIC 3467)
Asheville	North Carolina	704/255-0021	(212A)
Charlotte	North Carolina	704/376-2545	
Charlotte	North Carolina	704/376-2544	(212A)
Durham	North Carolina	919/549-8952	(VADIC 3467)
Fayetteville	North Carolina	919/323-4202	(VADIC 3467)
Greensboro	North Carolina	919/379-0470	(VADIC 3467)
High Point	North Carolina	919/885-0171	(VADIC 3467)
Raleigh	North Carolina	919/832-1551	(VADIC 3467)
Winston-Salem	North Carolina	919/725-9252	(VADIC 3467)
Fargo	North Dakota	701/280-3000	(VADIC 3467)
Akron	Ohio	216/535-1861	(VADIC 3467)
Cincinnati	Ohio	513/489-2100	(VADIC 3467)
Cleveland	Ohio	216/781-7050	(212A)
Columbus	Ohio	614/421-7270	
Columbus	Ohio	614/421-1650	(212A)
Dayton	Ohio	513/223-3847	(VADIC 3467)
Marysville	Ohio	513/642-2015	(212A)
Toledo	Ohio	419/243-3144	
Toledo	Ohio	419/255-2946	(212A)
Youngstown	Ohio	216/744-5326	(VADIC 3467)
Oklahoma City	Oklahoma	405/947-6387	(VADIC 3467)
Tulsa	Oklahoma	918/582-4433	(VADIC 3467)
Portland	Oregon	503/226-0627	(VADIC 3467)
Salem	Oregon	503/399-1453	(VADIC 3467)
Allentown	Pennsylvania	215/432-1500	(VADIC 3467)
Altoona	Pennsylvania	814/946-8888	(VADIC 3467)
Downington	Pennsylvania	215/269-9861	(VADIC 3467)
Erie	Pennsylvania	814/453-7161	
Harrisburg	Pennsylvania	717/233-8531	(VADIC 3467)
King of Prussia	Pennsylvania	215/337-9900	(VADIC 3467)
Philadelphia	Pennsylvania	215/567-1381	(212A)
Pittsburgh	Pennsylvania	412/765-1320	(VADIC 3467)
Reading	Pennsylvania	215/372-4474	(VADIC 3467)
Scranton	Pennsylvania	717/342-2593	(VADIC 3467)
Valley Forge	Pennsylvania	215/666-9190	(VADIC 3467)

(Continued)

TABLE 2 (continued)

City	State	Telephone No.	Modem
Wilkes Barre	Pennsylvania	717/822-0323	(VADIC 3467)
York	Pennsylvania	717/846-3900	(VADIC 3467)
Mayaguez	Puerto Rico	809/833-4535	(VADIC 3467)
Ponce	Puerto Rico	809/840-9110	(VADIC 3467)
San Juan	Puerto Rico	809/792-5900	(VADIC 3467)
Newport	Rhode Island	401/847-0502	(VADIC 3467)
Providence	Rhode Island	401/273-0200	(VADIC 3467)
Charleston	South Carolina	803/577-2179	(VADIC 3467)
Columbia	South Carolina	803/252-0840	(212A)
Columbia	South Carolina	803/256-5238	(212A)
Greenville	South Carolina	803/271-2418	(212A)
Greenville	South Carolina	803/271-9967	
Spartanburg	South Carolina	803/585-2637	(VADIC 3467)
Sioux Falls	South Dakota	605/335-0780	(VADIC 3467)
Chattanooga	Tennessee	615/756-5856	
Chattanooga	Tennessee	615/756-0561	(212A)
Knoxville	Tennessee	615/637-3118	(VADIC 3467)
Memphis	Tennessee	901/529-0170	
Memphis	Tennessee	901/529-0183	(212A)
Nashville	Tennessee	615/367-9382	(VADIC 3467)
Austin	Texas	512/444-3280	(VADIC 3467)
Baytown	Texas	713/427-5856	
Beaumont	Texas	713/832-2589	
Corpus Christi	Texas	512/883-8050	(VADIC 3467)
Dallas	Texas	214/638-8888	(VADIC 3467)
Dallas	Texas	In-Texas Wats	(VADIC 3467)
Dallas	Texas	National Wats	(VADIC 3467)
El Paso	Texas	915/533-1453	(VADIC 3467)
Fort Worth	Texas	214/263-4581	(VADIC 3467)
Houston	Texas	713/977-4080	
Houston	Texas	713/977-7671	(212A)
Houston	Texas	713/975-0500	(VADIC 3467)
Longview	Texas	214/758-1756	(VADIC 3467)
Lubbock	Texas	806/762-0136	
Midland	Texas	915/683-5645	(VADIC 3467)
Odessa	Texas	915/563-3745	(VADIC 3467)
San Antonio	Texas	512/225-8002	(VADIC 3467)
Tyler	Texas	214/592-1372	(VADIC 3467)
Waco	Texas	817/752-1642	(VADIC 3467)
Wichita Falls	Texas	817/761-1315	(VADIC 3467)
Salt Lake City	Utah	801/364-0780	(VADIC 3467)
Burlington	Vermont	802/658-2123	(VADIC 3467)
Charlottesville	Virginia	804/971-1001	(VADIC 3467)
Fairfax	Virginia	703/691-8200	(VADIC 3467)
Lynchburg	Virginia	804/528-1903	(VADIC 3467)
Midlothian	Virginia	804/744-4860	(VADIC 3467)
Newport News	Virginia	804/596-7609	(VADIC 3467)
Norfolk	Virginia	804/625-8301	(212A)

(Continued)

TABLE 2 (continued)

City	State	Telephone No.	Modem
Richmond	Virginia	804/744-4860	(VADIC 3467)
Roanoke	Virginia	703/345-4730	(VADIC 3467)
Williamsburg	Virginia	804/872-9592	(VADIC 3467)
Enumclaw	Washington	206/825-6576	(VADIC 3467)
Olympia	Washington	206/754-3900	(VADIC 3467)
Richland	Washington	509/375-3367	(VADIC 3467)
Seattle	Washington	206/285-0109	(VADIC 3467)
Spokane	Washington	509/747-4105	(VADIC 3467)
Tacoma	Washington	206/473-7810	(VADIC 3467)
Charleston	West Virginia	304/345-2908	(212A)
Huntington	West Virginia	304/522-6261	
Appleton	Wisconsin	414/735-9390	(VADIC 3467)
Brookfield	Wisconsin	414/785-1614	(VADIC 3467)
Eau Claire	Wisconsin	715/834-7863	(212A)
Green Bay	Wisconsin	414/437-9897	(VADIC 3467)
Madison	Wisconsin	608/221-4211	
Madison	Wisconsin	608/221-0891	(212A)
Milwaukee	Wisconsin	414/785-1614	(VADIC 3467)
Neenah	Wisconsin	414/722-5580	(VADIC 3467)
Oshkosh	Wisconsin	414/235-1082	(VADIC 3467)
Racine	Wisconsin	414/632-3006	(VADIC 3467)

NOTE: If local dial service is not available, users are requested to contact the Communications Staff of User Services at (919) 541-4506. They will assign a telephone number for access to TYMNET.

Modem: If not marked, the telephone number is compatible with a BELL modem at 300 baud.

212A = The telephone number is compatible with a BELL modem at 300 or 1200 baud.

VADIC 3467 = The telephone number is compatible with a BELL modem at 300 or 1200 baud, and with a VADIC modem at 1200 baud.

VADIC 1200 = The telephone number is compatible with a VADIC 3400 modem.

1200 202S = The telephone number is compatible with a BELL modem at 1200 baud with half duplex only. Users must ensure that the destination host interface will accept true half duplex operation (most will not).

CCITT = The telephone number is compatible with a European type modem at 1200 baud.

orient it as marked on the coupler. (On terminals that do not require an acoustic coupler, depress the "data" button and then hang up the phone.)

(5) The following message will appear at your terminal (although it will be garbled at speeds other than 300 or 1200 baud):

```
PLEASE TYPE YOUR TERMINAL IDENTIFIER
```

Upon receipt of this message, type your terminal identifying character (which can be found in Table 3).

(6) TYMNET will then display:

```
-XXXX-YYY-
PLEASE LOG IN:
```

(XXXX is a code for the TYMNET node to which you are connected, and YYY is the port on that node.)

Note: This message sent from TYMNET has no parity. If your terminal is checking for parity, this message may be garbled.

Respond by typing UNIEPA1, followed by a carriage return. If you need or want to enter additional information, this should be done in the form of one or more of the following control characters before typing UNIEPA1:

CONTROL H	Suppresses TYMNET echoing of input characters. This affects only the input UNIEPA1--once connected to the UNIVAC, input will not be echoed even without typing CONTROL H.
CONTROL P	Provides/ensures that data received at your terminal will have even parity. Although UNIVAC output will have even parity, TYMNET messages normally do not.
CONTROL X	Tells TYMNET to control the flow of data from your terminal (towards the UNIVAC) with XON and XOFF to prevent input data loss. This is normally necessary if you are inputting from paper tape, cassette, or internal buffer.
CONTROL R	Tells TYMNET that your terminal will be controlling the flow of data to your terminal (from the UNIVAC) with XON and XOFF to prevent output data loss.

TABLE 3. TERMINAL IDENTIFIERS

Terminal	ID[a]	Terminal	ID[a]
ADDS		ITT	
580, 620, 680, 880, 980	A	3501 Asciscope	A
Anderson Jacobson		Lear Siegler	
330	[Cr]	7700, ADM-1, ADM-2, ADM-3, ADM-31	A
830, 832	A	LogAbax Informatique	
630[b]	E	LX180	I
860[b]	A	LX 1010[b]	A
Ann Arbor Terminals		MP	
Design III, 200	A	2400[b]	I
Beehive Medical Electronics		Megadata	A
Mini Bee 1, 2, 4	A	Memorex	
Super Bee 2, 3	A	1240	G
I-211, M-501, R-211	A	NCR	
Bell System		260	E
Dataspeed 40/2		796	A
KD	A	Omron	
KDP	G	8525	A
Computer Devices		Ontel	
1030	E	4000	A
1132, 1201, 1202, 1203, 1204, 1205, 1206	A	Perkin-Elmer	
Computek		1200, 1250	A
200, 300	A	Research	
Conrac		Teleray 3300, 3311, 3712	A
401, 480	A	Raytheon	
Control Data		PTS-100	A
713	A	Singer	
Computer Transceiver Systems		30	E
Execuport	E	Scientific Measurement Systems	
DEC		1440	A
GT40, LA34, LA36, LA38, LA120,[b] LS120,[b] VT05, VT50, VT100, VT132	A	Tally	
Datamedia		1612[b]	A
1500, 2000, 2100, 2500	A	Tec	
Datapoint		400 Series, 1440	A
1100, 3000, 3300	A	Tektronix	
Delta Data		4012, 4013, 4014, 4023, 4025	A
5000, 5100, 5200	A	Teletype	
Digi-Log		33, 35	D
33, 209, 300	A	38	B
General Electric Terminet		43	A
300, 1200	G	Texas Instruments	
Gen-Com		720, 725, 733, 735, 743, 745, 763, 765, 771,[b] 820[b]	A
300	A	Texas Scientific	
Hazeltine		Entelkon 10	A
1200, 2000	A	Typagraph	
Hewlett-Packard		DP-30	C
2615, 2616, 262X Series, 263X Series, 264X Series, 7220A[b]	A	Tymshare	
Hydra		100, 110, 212, 213	E
Model B	I	200	D
IBM		310, 311	C
2741	P[Cr]	125, 126, 225, 315, 316, 325, 350,[b] 420, 425,[b] 430, 440W, 444,[b] 470,[b] 550, 1100[b]	A
Interdata		Wang Laboratories	
Carousel 300	E	220 OB	A
Incoterm		Westinghouse	
SPD 10/20, 20/20, 900	A	1600, 1620	A
Infoton		Xerox	
Vistar	A	BC100, BC200	A

---

[a] The symbol [Cr] represents a carriage return.

[b] During log-in, enter Control R immediately before typing your user name.

(7) TYMNET will prompt for the password with:

```
PASSWORD:
```

Respond by typing NCC, followed by a carriage return. (Passwords are not echoed.)

(8) Once the connection is made to the UNIVAC you will receive:

P### (### is a code for the UNIVAC port) and:

```
UNIV IS ON LINE
```

Upon recept of this message, enter:

UNIVAC (followed by a carriage return)

The characters UNIVAC must be even parity, uppercase ASCII to initiate a session on the UNIVAC.

(9) The UNIVAC will respond with:

```
ENTER USERID/PASSWORD:
```

Enter a valid USERID AND PASSWORD, separated by a slash and followed by a carriage return.*

(10) The UNIVAC will respond with:

```
*DESTROY USERID/PASSWORD ENTRY
*UNIVAC 1100 OPERATING SYSTEM LEV. XXXXXX*
```

possibly followed by some other log-on information.

Enter the following:

```
@@TTY∆C, [back space]
```

The [back space] refers to depressing the back space key. This command enables the user to use the back space key to correct typing errors. Normal response to this will be:

```
-@@COMPLETE
```

---

*Every 90 days, the system will automatically notify users that their password has expired. When this occurs, the user must enter a new password by typing USERID/OLD PASSWORD/NEW PASSWORD (followed by a carriage return).

(11) Enter the following (if using a CRT terminal this step should be ignored):

```
@@TTYΔW,132
```

This informs the computer that the terminal being used is capable of handling 132 character lines. The normal response to this will be:

```
-@@COMPLETE
```

(12) Enter a valid @RUN statement, which consists of the following:

```
@RUNΔ[RUNID],[ACCOUNT NUMBER],FGD/FGDIP
```

Note: The RUNID is a user-supplied value that should consist of a two digit bin number immediately followed by the user's initials. The bin number should correspond to the NCC bin to which any output that might be printed at the NCC should be directed (i.e., an EPA Region IV user would select the bin assigned to Region IV). See Section 4 for further information and a listing of EPA regional office bin numbers.

(13) When an acceptable run has been established, the response will be:

```
DATE-------- TIME--------
***  NEWS CURRENT AS OF (TIME----) ON (DATE----)  ***
```

(14) At this point, you are logged into the UNIVAC 1100 system. The computer will provide the character ">" for input solicitation.

A sample runstream is as follows:

```
please type your terminal identifierA       *DESTROY USERID/PASSWORD ENTRY
-3110-026-                                  *UNIVAC 1100 OPERATING SYSTEM  LEV. 38R5A-80-11A(RSI)*
please log in:UNIEPA1                       >@@TTY C,
                                            -@@COMPLETE
password:                                   >@@TTY W,132
[redacted]                                  -@@COMPLETE
P  2                                        >@RUN 80ABC,ACCOUNT #,FGD/FGDIP
UNIV IS ON LINE                             DATE: 030784      TIME: 103504
UNIVAC                                      *** NEWS CURRENT AS OF 14:00:19 ON 03/05/84 ***
[redacted]   ENTER USERID/PASSWORD:
                                            >
```

3.1.2 Computer Log-Off

The following is the procedure for terminating a session on the UNIVAC 1100:

(1) After the run is complete, type @FIN.

(2) Some computer log-off information will be printed, followed by *TERMINAL INACTIVE*. When this is received, type @@TERM to terminate the terminal.

After a UNIVAC @@TERM, TYMNET will prompt you to log in again. At this point, you may initiate a new UNIVAC session or you may simply hang up.

3.2 SYSTEM 2000 EXECUTION/TERMINATION

Once an active run has been initiated, the next step is to access the data base by executing SYSTEM 2000. This can be accomplished with the following command:

```
@ADD FGDIS.RUN
```

This command will initiate execution of SYSTEM 2000 and assign the FGDIS to the run. The normal response will be:

```
DATE----- TIME----- BEGIN SYSTEM 2000 VERSION 2.90A

---

-556-ASSIGNED...FGDIS (followed by the date and time that the data base
was last updated)

---

>
```

At this point, the data base is ready for use and the various Immediate Access or Report Writer features can be initiated.

When all queries have been satisfied and you want to terminate use of the data base, enter the following command:

```
---

>EXIT:
```

The normal response to this will be:

```
DATE----- TIME----- END SYSTEM 2000 VERSION 2.90A
```

After receipt of the computer prompter (>), normal computer log-off procedures can be initiated (see Section 3.1.2).

3.2.1 Output Interrupt

Occasionally, a user may wish to terminate or interrupt the output generated from a particular command after the command has already been entered and processing has begun. This can be accomplished with the use of the "Output Interrupt" or "Break" key, followed by a control statement. The two control statements used most often are @@X and @@XΔTIO.

The use of @@X only terminates the immediate function entered. In this case, processing continues internally; however, the output is not displayed. Eventually, the prompter (>) will return and the user may continue.

The use of @@XΔTIO will terminate the immediate function as well as execution of SYSTEM 2000. In this case, should the user wish to continue accessing FGDIS, he/she must reinitiate execution with @ADD FGDIS.RUN. Note: The cost to the user may differ depending on which control statement is used. For example, use of @@X following the interruption of what would have been a lengthy output will not terminate the internal processing, and the user will be charged for any computer time used. On the other hand, use of @@XΔTIO terminates execution of SYSTEM 2000 and therefore immediately terminates all processing of the function.

3.3 IMMEDIATE ACCESS FEATURES

The Immediate Access feature of SYSTEM 2000 provides the data base user with various commands for the retrieval and manipulation of data that are stored within the assigned data base. The commands range from the very simple and general to the more complex and specific. These commands generally take the form of PRINT <something>, or PRINT or LIST <something> WHERE <certain conditions exist>. The one most often used contains the WHERE clause to qualify certain portions of the data base for possible retrieval. This can be a powerful tool when used in conjunction with a keen knowledge of the data base structure. The following sections describe the structure and use of the retrieval commands available. It should be noted that all commands within SYSTEM 2000 must be followed by a colon (:). Lengthy commands may be continued in several lines by using the carriage return; however, the colon indicates completion of a command. The maximum number of input characters per line is 80.

3.3.1 DESCRIBE Command

The purpose of the DESCRIBE Command is to retrieve a copy of the data base definition or a portion of a copy.

Format--

```
(1) DESCRIBE:

(2) DESCRIBE <component number>:

(3) DESCRIBE <component number> THROUGH <component number>:

(4) DESCRIBE <component number> THRU <component number>:
```

The first option produces a complete copy of the data base definition, including each repeating group and all its components. The other three options are used to retrieve descriptions of single or multiple components. If the component number referenced in the command is not present in the data base, an error diagnosis will result.

The first option also produces four lines of header information, as follows:

```
SYSTEM VERSION NUMBER <n>
DATA BASE NAME IS <data base name>
DEFINITION NUMBER <n>
DATA BASE CYCLE NUMBER <n>
```

The version number of SYSTEM 2000 used to create the data base and the name of the data base are given first, and are followed by the current Definition and Data Base Cycle Number. When the definition is first created and the data are first loaded, these last two numbers are set to one (1). If the definition or the data are modified, the Definition and Data Base Cycle Numbers are incremented appropriately.

3.3.2 TALLY Command

The purpose of the TALLY Command is to provide the user with statistical information about the unique values that are to be found within a specified element(s) of the data base.

<u>Format</u>--

```
(1)  TALLY <element list>:

(2)  TALLY/EACH/<element list>:

(3)  TALLY/ALL/<element list>:
```

where:

<element list> = one or more element names or numbers separated by commas

The two basic TALLY options are TALLY/EACH/<element list> and TALLY/ALL/<element list>. EACH and ALL are both format statements that are germane only to the TALLY command. EACH is the default condition, and it is assumed if neither EACH nor ALL is used in the command (as in the first format).

The TALLY/EACH/ command produces output that provides the name of the element, a listing of each unique value stored for that element (along with its frequency of occurrence), and a summary section that gives the total number of unique values and the total number of data values stored for the element.

The following is a sample output:

```
********************************************
 ITEM-         PLANT EPA REGION
********************************************
OCCURRENCES   VALUE
--------------------------------------------
         2      1
         4      2
        24      3
        53      4
        42      5
        46      6
        16      7
        44      8
        23      9
         4     10
--------------------------------------------
       10 DISTINCT VALUES
--------------------------------------------
      258 TOTAL OCCURRENCES
--------------------------------------------
```

If the command had been TALLY/ALL/ for the same element, the following format would have resulted:

```
*******************************************
 ITEM-        PLANT EPA REGION
*******************************************
 MINIMUM-      1
-------------------------------------------
 MAXIMUM-     10
-------------------------------------------
       10 DISTINCT VALUES
-------------------------------------------
      258 TOTAL OCCURRENCES
-------------------------------------------
```

The difference between the two outputs is as follows: the output produced by TALLY/EACH/ command contains each unique value for the specified element along with the frequency of its occurrence; whereas, the output produced by the TALLY/ALL/ command contains minimum and maximum unique values only.

If more than one element is specified in the element list, the reports for each will be output one after the other in the order specified (as shown in the preceding example).

The SINGLE SPACE, DOUBLE SPACE format statements specified in a previous PRINT or LIST command affect the output format of this command.

Restrictions--

(1) A maximum of 100 elements may be included in the <element list> of one TALLY command.

3.3.3 PRINT Command

The purpose of the PRINT command is to retrieve data specified in the <print clause> from the data base and to output that data in a simple sequential list.

Format--

(1) PRINT <print clause>:

(2) PRINT <print clause>, <ordering clause> WHERE <conditions exist>:

where:

<print clause> = <option list>, <by clause(s)>, or <object list(s)>

<ordering clause> = an optional portion of the command used to order the output (see Section 3.3.7)

<conditions exist> = series of legal WHERE clause conditions

<option list> = one or more format option statements separated by commas, and the entire list set off by slashes (see Section 3.3.4)

<by clause(s)> = one or more BY clauses separated by commas, each one having its own object list (see Section 3.3.9)

<object list(s)> = element references (name or number) or repeating group references

The PRINT command produces a simple sequential list of output, as shown in the examples in this section. As the formats specified above indicate, the PRINT command has two basic forms--one with and one without a WHERE clause. The first one shown (the one without a WHERE clause) results in tree-order output; i.e., the data output will reflect the hierarchical structure of the data base, as illustrated in the FGDIS structure diagram (Section 2.1).

When no formatting options are specified (i.e., all formatting options are in their default state), the output from a PRINT command is consistent with the following example:

```
---
>PRINT C5,C7,C8,C102,FUEL TYPE:
  5* ALABAMA ELECTRIC COOP
  7* TOMBIGBEE
  8* 2
    102* PULVERIZED COAL
      201* COAL
  5* ALABAMA ELECTRIC COOP
  7* TOMBIGBEE
  8* 3
    102* PULVERIZED COAL
      201* COAL
  5* MONONGAHELA POWER
  7* PLEASANTS
  8* 1
    102* PULVERIZED COAL
      201* COAL
```

The example shows the component name and "C-number" format. It also illustrates several characteristics of standard output format (changeable by the option list):

(1) The element stub is associated with the element values. The stub consists of the element number or name and the system separator.

(2) Hierarchical level differences are indicated by a two-space indentation between levels.

(3) The system double spaces before data sets when printing repeating groups or when the GROUP format option has been invoked prior to printing elements.

If the object list contains a repeating group, the associated output will include the contents of every data set identified by that repeating group and all of its descendant data sets. Obviously, a massive amount of output can accompany such a command. Thus, any example at this point would, of necessity, underplay the extent of the output.

When the command includes a WHERE clause, this clause is processed first so that only that portion of the data base that qualifies for the specified conditions will be considered for output. The WHERE clause is discussed further in Section 3.3.10; however, an example is shown here:

```
---
>PRINT C5,C7,C8,C201 WHERE C5 EQ CINCINNATI GAS & ELECTRIC:
  5* CINCINNATI GAS & ELECTRIC
  7* EAST BEND
  8* 2
     201* COAL
  5* CINCINNATI GAS & ELECTRIC
  7* EAST BEND
  8* 1
     201* COAL
```

The intent of the following collection of examples is to illustrate at least one of each type of PRINT command. These examples emphasize the <print clause> rather than the WHERE clause.

(1) PRINT <object list>:

```
PRINT C5,C7,C8:
PRINT C803,MAX C810:
PRINT BOILER SUPPLIER,FUEL TYPE:
PRINT(C22 - C23):
```

(2) PRINT/<option list>/:

```
PRINT/REPEAT SUPPRESS,NULL,BLOCK,NAME/:
PRINT/DOUBLE SPACE,NUMBER/:
PRINT/GROUP,STUB SUPPRESS/:
```

(3) PRINT/<option list>/<object list>:

```
PRINT/REPEAT/C5,C102,C201:
PRINT/STUB/SIGMA C19:
```

(4) PRINT <by phrase>,<object list>:

```
PRINT BY ENTRY,C1,COUNT C1004:
```

(5) PRINT <by phrase>,<object list>:

```
PRINT C1,C102,BY C100,MAX C213,MIN C213,AVG C213:
PRINT BY ENTRY,C1,COUNTY C102,COUNT C201,BY C100,C102,C201:
```

(6) PRINT <print clause> WHERE <conditions exist>:

```
PRINT/REPEAT SUPPRESS/C5,C7,C8 WHERE C803 EQ LIME:
DITTO WHERE C809 EQ NEW:
```

(7) PRINT <print clause> WHERE <conditions exist>:

```
PRINT/REPEAT SUPPRESS/C5,C7,C8,OB C5,C7,C8 WHERE C809 EQ NEW:
```

Note: When the object list contains unrelated, disjointed elements or repeating groups and a WHERE clause is included, the <print clause> must contain a <BY clause>, which is discussed in Section 3.3.9. Unrelated or disjoint components are defined as those that are not a part of the same repeating group family; e.g., Element 1105, ABSORBER GENERIC TYPE is a member of the ABSORBER repeating group in the FGDIS definition and would be disjoint with Element 1005, QUENCHER/PRESATURATUR TYPE, which is a member of the QUENCHER/PRESATURATOR repeating group.

3.3.4 Format Statements

The purpose of the Format Statements is to provide a means of modifying the format of retrieval output.

Format--

(1) PRINT/<option list>/:

(2) PRINT/<option list>/<print clause>...:

(3) LIST/<option list>, TITLE <title specifications>/<list clause>...:

where:

<option list> = one or more format option statements separated by commas

/ (slash) = the mandatory symbol used to set off the option list, when used

When a PRINT command contains an option list, the options within that list are active on all data items specified in the command. Furthermore, if the option list contains format statements (as discussed in this section), these format options are not only active on the associated data items, but also on all subsequent data items in subsequent retrieval commands within that job until superseded by replacement options.

The format options available to the user are as follows:

Format Statements--

(1) SINGLE SPACE
DOUBLE SPACE

(2) INDENT
BLOCK

(3) NUMBER
NAME

(4) STUB
STUB SUPPRESS

(5) NULL SUPPRESS
NULL

(6) TREE
GROUP

(7) REPEAT
REPEAT SUPPRESS

(8) ZERO SUPPRESS
ZERO

The default condition of each option pair is the option on top. Some options are quite straightforward in their meaning; other option-pairs are more complex. A discussion of each follows.

(1) SINGLE SPACE - All output is single-spaced.

DOUBLE SPACE - All output is double-spaced.

(2) INDENT - Each hierarchical level of output in ascending order (0,1,2, ... n) is indented by two spaces.

BLOCK - All output lines are left justified.

(3) NUMBER - The element stub (or element identifier) will appear as the component number followed by the system separator (*).

NAME - The stub will appear as the component name followed by the system separator.

(4) STUB - With the stub in effect, the component stub will appear.

STUB SUPPRESS - The component stub will not appear.

(5) NULL SUPPRESS - When data sets are constructed by the user, they do not always contain all element values for that repeating group. When a defined element is unvalued in a data set, binary zeroes are actually stored in the tables where the element value is defined to be. With the NULL SUPPRESS option in effect, unvalued elements that would have output if they had been valued will have no associated output (i.e., the element will not appear at all in the output).

NULL - When the NULL option is in effet, all elements that are requested in the PRINT command will have output whether valued or not. For unvalued elements, the element stub will print -NULL- in association with the value. This option will not affect LIST output.

(6) TREE - A request to print a repeating group will produce that repeating group as well as all of its descendant data sets.

GROUP - When the GROUP option is in effect, a request to print a repeating group will print that group only and not the descendant data sets that might be associated with the selected repeating group.

(7) REPEAT - With this default condition in effect, a command to print several successive data sets that share a common ancestor will cause the common ancestor data set to print before each successive data set is output (i.e., the common ancestor data set will be repeated many times).

REPEAT SUPPRESS - The elements of a common ancestor data set will print only once when requesting a printout of successive data sets that are joined to the common ancestor.

(8) ZERO SUPPRESS - This default condition causes -NULL- values to be treated as null when used in a user-defined function (e.g., mathematical expression). A null value in a user-defined function produces a null result.

ZERO - This option directs a null valued component to be treated as a zero when it is used in a user-defined function. This option applies to system functions SUMM, COUNT, AVG, MIN, MAX, SIGMA only if the object of the system function is presented as an in-line function (Section 3.3.6).

Example:

```
PRINT/ZERO/SUM C21 ... (no effect; null values will be ignored)

PRINT/ZERO/SUM (C21+0) ... (null treated as zero)
```

The EACH and ALL options of the TALLY command described in Section 3.3.2 are available within the TALLY command only.

Restrictions--

(1) Once called, a format option remains in effect throughout a given job unless the inverse option is requested.

(2) Options (1) through (8) apply to the PRINT command.

(3) Options (1), (7), and (8) apply to the LIST command.

(4) Option (1) affects the output of the DESCRIBE and TALLY command.

(5) REPEAT SUPPRESS has no effect on a PRINT or LIST command without a WHERE clause; in this case the output is always in tree order.

3.3.5 System Functions

The purpose of the system functions is to permit the user to obtain arithmetic statistics about the data values contained in the data base.

Format--

... <function name><function object>

where:

<function name> = any of the six functions MIN, MAX, AVG, SUM, COUNT, SIGMA

<function object> = any element, repeating group, or user-defined function

The six system functions--MIN, MAX, AVG, SUM, COUNT, and SIGMA--are provided to operate on the contents of the data base. Except as noted in the Restrictions section, the system functions may be used to operate on any element or repeating group in the data base.

The command word for each system function is presented here, along with an explanation of the function:

MAX	The maximum value of any data item*
MIN	The minimum value of any data item*

---

* Note: Alphabetic items in NAME and TEXT fields are ordered low to high from A to Z.

COUNT	COUNT is the function that counts the number of times something occurs. Therefore, any data type may be used, including RG's.
SUM	SUM is the function used to add the numeric value of requested elements. Only data types INTEGER and DECIMAL may be used with the function SUM.
AVG	AVG is the standard average calculation, $\frac{\Sigma X}{n}$, which may be applied to data types INTEGER and DECIMAL.
SIGMA	SIGMA computes the standard deviation of data types INTEGER and DECIMAL using the following formula:

$$\text{SIGMA} = \frac{\Sigma X^2 - \frac{(\Sigma X)}{n}}{n-1}$$

The output format associated with the six system functions includes the name of the system function in the stub. In all cases, a three-letter abbreviation is used, as illustrated in the hypothetical example:

Given: (1) C1 is a type INTEGER element

(2) C1 exists in 5 data sets

(3) The five values for C1 are 5,5,3,3, and 1.

```
PRINT MAX C1,MIN C1,COUNT C1,SUM C1,SIGMA C1,AVG C1:
```

```
MAX 1*   5
MIN 1*   1
CNT 1*   5
SUM 1*   17
SIG 1*   1.673
AVG 1*   3.400
```

Note that AVG and SIGMA output show results rounded to three decimal places. This is also true for SUM output if DECIMAL values are included in the SUM. Because COUNT produces a count of existing elements or RG's, a command such as PRINT COUNT C1 WHERE C1 FAILS: will always produce the value zero. To count the number of times an element fails, an appropriate command would be:

```
PRINT COUNT <repeating group> WHERE <element> FAILS:
```

i.e., print the count of occurring data sets for which the element is non-valued.

Restrictions--

(1) The system function COUNT may be used to count the occurrences of repeating groups; none of the remaining functions may reference repeating groups.

(2) SUM, SIGMA, and AVG may be used only with numeric type elements (INTEGER and DECIMAL).

(3) The six system functions cannot be used in a WHERE clause.

(4) No system function can reference more than one item. If multiple items are to be processed, the function name must be repeated with each item (for example, SUM C21,SUM C23... etc.).

Note: An item may be an in-line function such as (C21+C22) so that SUM(C21+C22) is legal.

(5) If enclosed in an in-line function, the system function must be enclosed in parentheses by itself.

(6) The ZERO, ZERO SUPPRESS format option has no effect on system functions unless the object of the system function is presented as an in-line function enclosed in parentheses.

3.3.6 In-Line Function

The purpose of an in-line function is to allow the user to express a mathematical function with a command.

Format--

```
(1)  PRINT ... (<in-line function>) ...:

(2)  PRINT ... (<in-line function>) ... WHERE ...:

(3)  LIST/.../... (<in-line function>) ... WHERE ...:

                      HIGH
(4)  ... ORDERED BY   LOW   (<in-line function>) ...
```

An in-line function is an arithmetic expression, which may contain element names or numbers, operand symbols, and constants. It can only contain numeric type elements (INTEGER, DECIMAL), and the entire function definition must be enclosed in parentheses. The following operational symbols may be used:

+ Addition
- Subtraction
* Multiplication
/ Division

The user may not specify the output format for the in-line function. Because mixed mode mathematics are allowed, the system assigns the output mode of the highest data type used, and DECIMAL fields take priority over INTEGER fields. Also, because the user cannot assign a component number to the in-line function, the system assigns component numbers to the in-line functions starting with the number 5001.

Any of the six system functions may be used with an in-line function.

The following examples illustrate some valid PRINT statements that use in-line functions:

```
PRINT (C21/100) WHERE COMPANY NAME EQ DETROIT EDISON:

PRINT C5,C7,C8,(C115*12) WHERE C115 EXISTS:

PRINT (C1128-C1134) WHERE C803 EQ LIME:
```

Restrictions--

(1) Only numeric INTEGER and DECIMAL type elements may appear within a function.

(2) If used within an in-line function, a system function must be enclosed in parentheses by itself.

3.3.7 Ordering Statement

The purpose of the ordering statement is to control and thus alter the standard output order for those items in the <object list> of any PRINT or LIST operation.

Format--

(1) PRINT <object list>, $\begin{bmatrix}\text{ORDERED BY}\\ \text{OB}\end{bmatrix}$ <ordering clause> WHERE ...:

(2) LIST/ ... /<object list>, $\begin{bmatrix}\text{ORDERED BY}\\ \text{OB}\end{bmatrix}$ <ordering clause> WHERE ...:

where:

<object list> = element or repeating group names and numbers, in-line function references, and system functions

<ordering clause> = $\begin{Bmatrix}\text{HIGH}\\ \text{LOW}\end{Bmatrix}$ <item$_1$>, $\begin{Bmatrix}\text{HIGH}\\ \text{LOW}\end{Bmatrix}$

<item$_n$> = an element or RG identifier, in-line or system function

The ordering clause is introduced by the words ORDERED BY or their abbreviation, OB. The output that results from the PRINT or LIST command will be ordered by the first element in the ordering clause, then by the second, and so on. Each element in the ordering clause may be introduced by the optional directives HIGH or LOW, with LOW being the default. The meanings of these two sort words are as follows:

LOW (default) = low-to-high (ascending) order, i.e., 1,2,3,4..., or A,B,C,D,....

HIGH = high-to-low (descending) order, i.e., 12,11,10,9..., or V,U,T,S....

The items that may be specified within the ordering clause are element name or "C" number, repeating group name or "C" number, and in-line function specifications or system functions. To be meaningful in an ordering clause, a system function must have a BY clause (see Section 3.3.9), e.g., ... OB SUM C21 BY ENTRY WHERE... If an RG is used in an ordering clause, all its descendant data sets will be output together.

Examples--

```
PRINT/NULL/C5,C7,C8,C14,C100, ORDERED BY PLANT EPA REGION WHERE C1 EXISTS:

PRINT C5,C7,C8,OB C5,C7,C8 WHERE C803 EQ LIME:
```

Restrictions--

(1) A command containing an ordering statement must include a WHERE clause.

(2) All items in the ordering clause must be in the same data base family.

3.3.8 LIST Command

The LIST command can be used to display output data in a columnar format with optional page headings and footings. The standard output from PRINT operations is a single vertical column of data. LIST command output is displayed in multiple columns, one column for each data item referenced in the command.

Sample Formats--

(1) LIST/<option list>,TITLE <title specifications>/:

(2) LIST/TITLE <title specifications>/<list clause>:

(3) LIST/<option list>,TITLE(<width>)<title specifications>/<list clause>, <ordering clause> WHERE <conditions exist>:

(4) LIST <list clause>,<ordering clause> WHERE <conditions exist>:

where:

<title specifications> = <page heading><page footing><column specifications>

<option list> = one or more format option statements separated by commas (see Section 3.3.4)

<list clause> = <by clauses> and <object lists> or just <object lists>

<ordering clause> = ordering option (see Section 3.3.7)

<conditions exist> = series of legal WHERE clause conditions

<by clauses> = one or more BY clauses separated by commas, each having its own object list (see Section 3.3.9)

<object list> = element references (name or number), in-line function references, and system functions. Repeating groups may not be used

(<width>) = page width, the maximum number of characters for a line of LIST output. Default = 71, Maximum = 131, Minimum = 4. If specified, it also positions the page number, right-justified at page width.

The third format illustrates the positioning of all the available specifications that can be used with the LIST command. Note that the <option list> and the <ordering clause> are optional items and need not be included. These are discussed in Sections 3.3.4 and 3.3.7 of this manual. The (<width>) refers to page width. This option can be used when the user requires more than 71 spaces of page width. The desired page width is enclosed in parentheses following the word TITLE and precedes the <column specifications>.

The <title specifications>, which is used only in the LIST command, consists of the following:

```
/TITLE <page heading>, <page footing>, <column specifications>/
```

Of these three, only the <column specifications> is mandatory if a TITLE specification is to be used. The <page heading> and <page footing> options are specified according to the following format:

```
page heading = D(<nn>)<text>,
page footing = F(<mm>)<text>,
```

If either or both of these are to be used, they must follow the word TITLE (or <width> specification, if used) and precede all the <column specifications>, e.g.,

```
LIST/TITLE <column specifications>/...:

LIST/TITLE D(<nn>)<text>,<column specifications>/...:

LIST/TITLE F(<mm>)<text>,<column specifications>/...:

LIST/TITLE D(<nn>)<text>,F(<mm>)<text>,<column specifications>/...:

LIST/TITLE (<width>)D(<nn>)<text>,F(<mm>)<text>,<column specifications>/...:
```

The "D(<nn>)<text>" allows the user to specify a report heading with the current date centered under the heading. The <nn> is the starting column of the heading "text." The heading will appear at the beginning of the report above the columnar headings.

The "F(<mm>)<text>" allows the user to specify a report footing and a page size. The <mm> specifies the number of lines that should appear on each page of "LIST" output. If both the "D" and "F" specifications are used, the LIST output per page will be <mm> minus 5 lines, including column headings. If only the "F" specification is used, the LIST output per page will be <mm> minus 2 lines, including column headings. The minimum number of lines per page is 10, and the maximum is 60. If the "D" specification is used, the page number will be printed on the heading line; if only the "F" specification is used, the page number will be printed on the footing line. If neither "D" nor "F" is used, there will be no page numbers. Page numbers are right-justified on the line (in the rightmost column indicated by the other LIST parameters), and they are limited to a maximum of four digits. It is up to the user to specify some meaningful label for the page number (such as "PAGE") and to locate the label next to the page number. The heading or footing <text> may be blank or null.

The column specifications may be made up of a single specification or several specifications separated by commas. Each specification can include two fields of format identification, <type> and <title>, but both are not required.

The <type> field is identified as:

```
          L
<type> =  R (<integer>)
          B
```

where:

```
        L = left-justified column <title>
        R = right-justified <title>
        B = column to be blank and its <title>, if any, left-justified
<integer> = number of character positions in this column
```

Examples of specified <type> fields are R(12), L(5), B(30), etc. If <type> is not specified, the <title> (which is simply the heading that will precede each column) will be left-justified and the column width will be specified implicitly by the size of the <title> specification.

The field width of a column is the maximum of (1) the <integer> value given in the <type> specification <u>or</u>, (2) the number of characters and blanks used in the <title> specification. Because the <title> specification is treated as text material, leading, trailing, and embedded blanks may be used to control the exact placement of each of the three available lines of the <title> specification if centering of the <title> words is important.

The <title> field may have any of the following forms:

```
<title> = (a)  <string of characters>
          (b)  <string of characters>+<string of characters>
          (c)  <string of char.>+<string of char.>+<string of char.>
          (d)  +<string of characters>
          (e)  +<string of characters>+
          (f)  ++<string of characters>
          (g)  +<string of characters>+<string of characters>
          (h)  <string of characters>+<string of characters>+
          (i)  <string of characters>++<string of characters>
```

where:

<string of char.> = the characters that will become the column heading, limited in number only by the output device in use

+ (plus sign) = indicates a new line, three lines allowable per column heading; also controls which lines will be blank

Using the title specifications just given, the following represents the resultant column header formats:

	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
Line 1	↔	↔	↔					↔	↔
Line 2		↔	↔	↔	↔		↔	↔	
Line 3			↔			↔	↔		↔

Columns that contain data are known as "material fields." There may be up to 40 material fields. Within these material fields, data types such as NAME and TEXT will be left-justified and have a wrap-around capability of up to five lines. All DECIMAL and INTEGER values will be right-justified and have no wrap-around capability. If the field width of the <specification list> is too narrow to contain the data, only the most significant digits will be displayed, and an asterisk will indicate overflow. For data types NAME and TEXT, the overflow asterisk will occur only on the fifth line.

The order in which items appear in the <object list> corresponds to the sequence of the material fields included in the <column specification>. If the <column specification> has fewer material fields than the <object lists>, the explicit assignments will apply to the leftmost items of the <object list> and default column headings, and field widths will be used for the remaining items.

In LIST output a line appears between the column headings and the first line of data, which consists of three asterisks starting from the left margin. The first character of the first field specification starts in the fourth column. With every line of non-wrapped-around data, an asterisk is printed in column one.

The NULL format option does not effect LIST output. If an entire line is NULL, it is omitted. If the data for a particular element are NULL, a blank will appear.

Some examples of the LIST command using the FGDIS data base are given below. The examples demonstrate a few possible variations of the LIST command. The more complex commands usually require some planning to help determine column lengths and specifications for the desired output. It is recommended that lengthy commands be stored in a file (see Appendix B) to simplify editing.

```
        ---
        >LIST C5,C7,C8,C201,OB C5,C7,C8 WH C213 GT 4.5:

        *  COMPANY NAME   PLANT NAME   UNIT NUMBER   FUEL TYPE
        ***
        *  ASSOCIATED E   THOMAS HIL   3             COAL
           LECTRIC        L
        *  DELMARVA POW   DELAWARE C   1             COKE
           ER & LIGHT     ITY
        *  DELMARVA POW   DELAWARE C   2             COKE
           ER & LIGHT     ITY
        *  DELMARVA POW   DELAWARE C   3             COKE
           ER & LIGHT     ITY
        *  GULF POWER     SCHOLZ       1A            COAL
        *  GULF POWER     SCHOLZ       1B,2B         COAL
        *  KANSAS CITY    LA CYGNE     1             COAL
           POWER & LIGH
           T
        *  LOUISVILLE G   CANE RUN     6             COAL
           AS & ELECTRI
           C
        ---
        >

 LIST/TITLE L(30)COMPANY+NAME,L(15)UNIT+NAME,UNIT+NUMBER,L(6)FUEL+TYPE/
---
>C5,C7,C8,C201,OB C5,C7,C8 WH C213 GT 4.5:

*  COMPANY                          UNIT              UNIT     FUEL
   NAME                             NAME              NUMBER   TYPE
***
*  ASSOCIATED ELECTRIC              THOMAS HILL       3        COAL
*  DELMARVA POWER & LIGHT           DELAWARE CITY     1        COKE
*  DELMARVA POWER & LIGHT           DELAWARE CITY     2        COKE
*  DELMARVA POWER & LIGHT           DELAWARE CITY     3        COKE
*  GULF POWER                       SCHOLZ            1A       COAL
*  GULF POWER                       SCHOLZ            1B,2B    COAL
*  KANSAS CITY POWER & LIGHT        LA CYGNE          1        COAL
*  LOUISVILLE GAS & ELECTRIC        CANE RUN          6        COAL
---
>
```

```
 LIST/TITLE B(25)SULFUR CONTENTS,
---
>F(20)FLUE GAS DESULFURIZATION INFORMATION SYSTEM,
---
>L(30)COMPANY+NAME,L(15)UNIT+NAME,UNIT+NUMBER,
---
>R(7)FUEL+SULFUR+CONTENT/C5,C7,C8,C213,OB C5,C7,C8 WH C213 GT 3.5:

                         SULFUR CONTENTS                    1
                           05/12/1983

*  COMPANY                        UNIT            UNIT      FUEL
   NAME                           NAME            NUMBER   SULFUR
                                                           CONTENT
***
*  ASSOCIATED ELECTRIC            THOMAS HILL     3          4.80
*  BIG RIVERS ELECTRIC            GREEN           1          3.91
*  BIG RIVERS ELECTRIC            GREEN           2          3.91
*  CINCINNATI GAS & ELECTRIC      EAST BEND       1          4.00
*  CINCINNATI GAS & ELECTRIC      EAST BEND       2          3.60
*  COLUMBUS & SOUTHERN OHIO ELEC  CONESVILLE      5          4.50
*  COLUMBUS & SOUTHERN OHIO ELEC  CONESVILLE      6          4.50
*  COMMONWEALTH EDISON            POWERTON        51         3.53
*  DELMARVA POWER & LIGHT         DELAWARE CITY   1          7.00
*  DELMARVA POWER & LIGHT         DELAWARE CITY   2          7.00
*  DELMARVA POWER & LIGHT         DELAWARE CITY   3          7.00

FLUE GAS DESULFURIZATION INFORMATION SYSTEM



                         SULFUR CONTENTS                    2
                           05/12/1983

*  COMPANY                        UNIT            UNIT      FUEL
   NAME                           NAME            NUMBER   SULFUR
                                                           CONTENT
***
*  GULF POWER                     SCHOLZ          1A         5.00
*  GULF POWER                     SCHOLZ          1B,2B      5.00
*  KANSAS CITY POWER & LIGHT      LA CYGNE        1          5.39
*  LOUISVILLE GAS & ELECTRIC      CANE RUN        4          3.87
*  LOUISVILLE GAS & ELECTRIC      CANE RUN        5          3.80
*  LOUISVILLE GAS & ELECTRIC      CANE RUN        6          4.80
*  LOUISVILLE GAS & ELECTRIC      MILL CREEK      1          3.75
*  LOUISVILLE GAS & ELECTRIC      MILL CREEK      2          3.75
*  LOUISVILLE GAS & ELECTRIC      MILL CREEK      3          3.87
*  LOUISVILLE GAS & ELECTRIC      MILL CREEK      4          3.75
*  LOUISVILLE GAS & ELECTRIC      PADDY'S RUN     6          3.70

FLUE GAS DESULFURIZATION INFORMATION SYSTEM
```

```
LIST/TITLE (110)D(39)BOILER & STACK CONVERSION TABLE,
L(30)COMPANY+NAME,L(20)UNIT+NAME,L(5)UNIT+NO.,
R(9)BLR. FLUE+GAS TEMP.+F      ,R(9)BLR. FLUE+GAS TEMP.+C      ,
R(7)STACK+HEIGHT+FEET,R(7)STACK+HEIGHT+METERS/C5,C7,C8,C109,
((C109-32)/1.8),C115,(C115*.3048),OB C5,C7,C8 WH C2 EQ
DOMESTIC AND C4 EQ SO2 & PARTICLE AND CO HAS C812 EQ 1:

                        BOILER & STACK CONVERSION TABLE
                                   03/07/1984

*  COMPANY                         UNIT                UNIT  BLR. FLUE  BLR. FLUE   STACK    STACK
   NAME                            NAME                NO.   GAS TEMP.  GAS TEMP.  HEIGHT   HEIGHT
                                                                   F          C      FEET   METERS
***
*  ALABAMA ELECTRIC                TOMBIGBEE           2          291    143.889      400  121.920
*  ALABAMA ELECTRIC                TOMBIGBEE           3          291    143.889      400  121.920
*  ARIZONA ELECTRIC POWER          APACHE              2          710    376.667      400  121.920
*  ARIZONA ELECTRIC POWER          APACHE              3          710    376.667      400  121.920
*  ARIZONA PUBLIC SERVICE          CHOLLA              1          276    135.556      250   76.200
*  ARIZONA PUBLIC SERVICE          CHOLLA              2          288    142.222      550  167.640
*  ARIZONA PUBLIC SERVICE          CHOLLA              4
*  ARIZONA PUBLIC SERVICE          FOUR CORNERS        1          340    171.111      250   76.200
*  ARIZONA PUBLIC SERVICE          FOUR CORNERS        2          340    171.111      250   76.200
*  ARIZONA PUBLIC SERVICE          FOUR CORNERS        3          340    171.111      250   76.200
*  ASSOCIATED ELECTRIC             THOMAS HILL         3                              650  198.120
*  BASIN ELECTRIC POWER            ANTELOPE VALLEY     1          310    154.444      600  182.880
*  BASIN ELECTRIC POWER            LARAMIE RIVER       1          286    141.111      600  182.880
*  BASIN ELECTRIC POWER            LARAMIE RIVER       2          133     56.111      600  182.880
*  BASIN ELECTRIC POWER            LARAMIE RIVER       3          157     69.444      600  182.880
*  BIG RIVERS ELECTRIC             GREEN               1          300    148.889      350  106.680
*  BIG RIVERS ELECTRIC             GREEN               2          300    148.889      350  106.680
*  CENTRAL ILLINOIS LIGHT          DUCK CREEK          1          275    135.000      500  152.400
*  CENTRAL ILLINOIS PUBLIC SERV    NEWTON              1          327    163.889      530  161.544
*  CINCINNATI GAS & ELECTRIC       EAST BEND           2          675    357.222      650  198.120
*  COLORADO UTE ELECTRIC           CRAIG               1          250    121.111      600  182.880
*  COLORADO UTE ELECTRIC           CRAIG               2          250    121.111      600  182.880
*  COLUMBUS & SOUTHERN OHIO ELEC   CONESVILLE          5          296    146.667      800  243.840
*  COLUMBUS & SOUTHERN OHIO ELEC   CONESVILLE          6          296    146.667      800  243.840
```

When using <width>, it is important to keep in mind not only the total maximum number of numeric and text characters for each column, but also the spaces the system provides. There will be three spaces at the beginning of each line of output (including an asterisk), as well as three spaces between each column.

If the column specifications are not completed within a line, the system fills the remainder of the line with blanks, which creates an undesirable (and usually unwanted) discrepancy in the specification. This can be prevented by completing the specification with a comma at the end of the line, and then starting the next line with the <type> statement for the next column.

3.3.9 BY Clause

The purpose of the BY clause is to permit retrieval of data from disjoint data sets. It can also be used to control the particular subsets of data on which system functions will operate. Whenever appropriate, it may be issued in conjunction with the PRINT and LIST commands.

Format--

```
(1) PRINT <object list>:

(2) PRINT <object list>, <by clause>, <by clause>:

(3) PRINT <by clause> WHERE <conditions exist>:

(4) PRINT <system function> <function object> <by phrase>:

(5) PRINT <object list>, <by clause>, <system function> <function object>
          <by phrase> WHERE <conditions exist>:
```

where:

<object list> = any item legally referenced in a <print clause>, including items from disjoint data sets

<by clause> = <by phrase>, <object list>

<by phrase> = BY followed by an RG name or number including "DATA BASE"

<conditions exist> = any of the legal WHERE clause conditions

<system function> = any of the six built-in system functions -- SUM, COUNT, etc.

<function object> = any component that may be legally operated upon by the associated function

The five formats shown have been selected to facilitate discussion of the BY clause concept; they do not represent all possible command structures incorporating BY clauses. In general, a command may contain any combination of items, including BY clauses, in a complex PRINT clause (as covered in the PRINT command discussion in Section 3.3.3). Format (5) is intended to represent the most general case.

A fundamental dichotomy relating to the BY clause concept is that if a command does not contain a WHERE clause, it always contains a BY clause, whether specified by the user or not. Conversely, if a command does contain a WHERE clause, it never has a BY clause unless specified by the user. In all cases, the presence of a BY clause controls the manner in which the data base is scanned and, consequently, the ordering of the output.

With the exceptions about to be explained, BY clause processing is identical in concept to the processing used with a PRINT <RG> command. The PRINT ENTRY command, for example, causes the entire data base, including disjoint data values, to be printed in tree order; i.e., in accordance with the logical rather than the physical order of data set placement. The only difference between BY clause processing and a PRINT <RG> command is that with a PRINT <RG> command, all qualifying element values are printed in tree order, grouped on an RG-by-RG basis. Because BY clause processing also scans the data base, it prints disjoint data values in tree order, but the output contains only the items specified in the <object list>; grouping will still be by the RG referenced in the <by phrase>.

By definition, the highest level RG that may be specified in a BY clause is DATA BASE, and in the absence of a WHERE clause, SYSTEM 2000 always assumes that the PRINT clause is enclosed in a BY DATA BASE phrase. The user also may specify the BY DATA BASE phrase. In either case, BY DATA BASE is assumed to reside at level -1, and it qualifies the entire data base for processing by the command. The following two commands produce identical results:

(1) PRINT C5,C102: (BY DATA BASE assumed)

(2) PRINT BY DATA BASE,C5,C102:

The output would also be the same if the <object list> were reordered, or if BY DATA BASE were replaced with BY ENTRY, as in the following:

```
(1)  PRINT C102,C5:  (BY DATA BASE assumed)
(2)  PRINT BY ENTRY,C102,C5:
```

The output ordering would be different, however, with the following command:

```
PRINT C5,BY DATA BASE,C102:
```

This command is actually of the form:

```
PRINT BY DATA BASE, (C5,BY DATA BASE,C102):
```

The <object list> of the first (or implied) BY DATA BASE phrase is everything within the brackets; i.e., the entire data base qualifies for tree order processing of the <object list>. Within the <object list>, SYSTEM 2000 processes begin with the highest level reference in the list. Items at the same level are processed in the order listed. In this case, because BY DATA BASE is the highest level item (BY DATA BASE is at the -1 level, whereas C5 resides at level 0), it is processed first and then followed by a listing of the C5 values.

Of the commands discussed so far, the two prefixed by (1) represent format (1) in the format example, and the remainder generally represent format (2). The commands given in format (2) contain only one BY clause.

In practice, the command may contain several separate BY clauses. Multiple BY clauses are separated, or terminated, by a WHERE clause, an ordering clause, another BY clause, or a colon.

All rules given thus far also apply when the command contains a WHERE clause [formats (3) and (5)]. The tree order processing of BY clauses again permits retrievals from disjoint data sets, and all rules that cover the ordering of output pertain. As stated at the outset, however, when commands have a WHERE clause, a BY clause must be explicitly included if disjoint data sets are to be accessed. In this case, SYSTEM 2000 does not assume a default of BY DATA BASE, as this would essentially contradict the purpose of the

WHERE clause, which is to restrict the qualifying portions of the data base to just those parts of the data base of interest.

This latter observation actually must be considered whenever a BY clause is included in a command containing a WHERE clause. The BY clause process, by definition, qualifies one or more trees of data sets, depending on the RG level specified. If BY DATA BASE is specified, the entire data base qualifies, and it is considered as a single tree in which the top node is at level -1. If BY ENTRY is specified, the top node is level 0, and every logical entry in the data base potentially qualifies for output.

When there is no WHERE clause, the number of trees that could qualify is equal to the number scanned for output. With a WHERE clause, however, only those trees are scanned that also satisfy the WHERE conditions. For instance, the command PRINT BY ENTRY, C5 WHERE C5 EQ DETROIT EDISON would produce the following output:

```
5* DETROIT EDISON
```

Although all entries were potentially qualified by the BY ENTRY phrase, the WHERE clause qualifies for processing only the entry DETROIT EDISON.

The user may find it helpful to look at commands containing both BY and WHERE clauses from the point of view just presented. Specifically, the presence of a BY clause potentially qualifies for listing every tree in the data base that has as its top node the RG specified in the BY clause; however, only those trees that "HAVE" the conditions specified in the WHERE clause qualify for final processing. In other words, the previous command could be thought of as having the following form:

```
PRINT BY ENTRY, C5 WHERE ENTRY HAS C5 EQ DETROIT EDISON:
```

An important application of the BY clause lies in its use to enclose one or more of the six system functions. This permits the user to restrict the calculation of the function to particular parts of the data base. When a BY clause is used for this purpose, it may be specified in either of two ways; complex commands may contain mixtures of the two. The first way of structuring the command is to include both the system function and its object in the

<object list> shown earlier in the first two formats; i.e., a command might be structured as follows:

```
PRINT BY ENTRY, C5, COUNT C201, C803, COUNT C1105:
```

If issued for the FGDIS, the result would look like the following:

```
 5* ALABAMA ELECTRIC COOP
CNT  201* 1
CNT  1105* 1
   803* LIMESTONE
 5* ALABAMA ELECTRIC COOP
CNT  201* 1
CNT  1105* 1
   803* LIMESTONE
 5* MONONGAHELA POWER
CNT  201* 1
CNT  1105* 1
   803* LIME
 5* ARIZONA ELECTRIC POWER COOP
CNT  201* 1
CNT  1105* 1
   803* LIMESTONE
 5* BASIN ELECTRIC POWER COOP
CNT  201* 1
CNT  1105* 1
   803* LIMESTONE
```

Other acceptable commands of this type are as follows:

```
PRINT BY C100, COUNT C102, SUM C108:

PRINT COUNT C102, BY ENTRY, SUM C108:

PRINT AVG C108, SUM C108, BY C100, C102:
```

The second way is represented by the following examples:

```
PRINT SUM C108 BY ENTRY:

PRINT C5, C100, SUM C213 BY C200:

PRINT SUM C108 BY C100, AVG C21 BY ENTRY:
```

Regardless of the way selected, the effect of enclosing a system function in a BY clause is to limit the calculation of that function to just that subset of the data base defined by the RG in the BY clause.

Restrictions--

(1) The RG specified in the BY clause must be at or above the highest hierarchical level referenced in the <object list>.

(2) Without a BY clause, disjoint data sets may not be specified in the object list.

3.3.10 WHERE Clause

The purpose of the WHERE clause is to specify the conditions required to qualify data sets from which retrievals or updates are to be made.

Format--

... WHERE <conditions exist>:

where:

<conditions exist> = any number of legal WHERE clause conditions as defined in the following statements:

(1) Unary Operator Condition

$$\langle\text{element}\rangle \quad \begin{bmatrix}\text{EXISTS}\\ \text{FAILS}\end{bmatrix}$$

(2) Binary Operator Condition

$$\langle\text{element}\rangle \quad \begin{bmatrix}\text{EQ}\\ \text{NE}\\ \text{LT}\\ \text{LE}\\ \text{GT}\\ \text{GE}\end{bmatrix} \quad \langle\text{value}\rangle$$

(3) Ternary Operator Condition

$$\langle\text{element}\rangle \quad \text{SPANS} \quad \langle\text{value}\rangle\langle\text{system separator}\rangle\ \langle\text{value}\rangle$$

$$\begin{bmatrix}\text{NE}\\ \text{EQ}\end{bmatrix}$$

(4) Normalized Condition

<repeating group> HAS <condition>

The WHERE clause is a fundamentally significant syntactic unit. The conditions modifying WHERE can be simple or complex combinations of restrictions on the qualifying data sets. All WHERE clauses use system operators of one type or another--such as EQUALS, GREATER THAN, and so forth. Although these are not discussed until a later section, an understanding of their meaning is assumed in the present discussion. Most are self-explanatory, and no more than brief reference to later material should be necessary in following this discussion.

The WHERE clause is used to focus data retrievals on just those segments of the data base of specific interest. In the absence of a WHERE clause, the entire data base qualifies, and the output includes every valued retrieval component specified. For example, considerable difference would be apparent in the output produced from the FGDIS data base by the issuance of these two commands:

```
PRINT COMPANY NAME:

PRINT COMPANY NAME WHERE PLANT STATE/COUNTRY EQ OHIO:
```

When a command contains a WHERE clause, the WHERE clause is processed first to determine which portion of the data base should be considered for those actions specified to the left of the WHERE clause.

Three new terms are explained at this point to assist in the understanding of the WHERE clause processing.

(1) Specified Data Sets - The data sets implicitly identified by the components listed to the left of the WHERE clause statement in a retrieval request. The component may be identified by name or by number. The data sets are implicitly identified by requesting elements within them or by naming the repeating group that generates the Specified Data Sets. The level within the data base structure where these Specified Data Sets occur is of great importance. If elements are used to identify the Specified Data Sets, these elements and the data sets will be at the same level because the elements come from within the data set. If a repeating group is used to identify the data sets, the Selected Data Sets will occur at one level below the listed repeating group.

(2) Qualified Data Sets - Data sets that satisfy the entire WHERE clause condition(s). When the system starts processing a command, it processes the WHERE clause first. Those data sets that satisfy all the conditions in the WHERE clause are temporarily "collected" and tested to see if any of the Qualified Data Sets are named or implied by the Specified Data Sets. If they are, they become:

(3) Selected Data Sets - Data sets produced from the Qualified Data Sets; that is, those data sets named by the Specified Data Sets and selected by qualification for retrieval.

As explained previously, some retrieval requests do not use the WHERE clause. If a request contains no WHERE clause, the entire data base qualifies for output. If no data sets satisfy the conditions imposed by the use of a WHERE clause, no action is taken on the request. If a list of Qualified Data Sets is produced, each Qualified Data Set is examined to see if it is also a Specified Data Set. If it is, it then becomes a Selected Data Set. If all components in the WHERE clause reference only the Specified Data Sets, all Qualified Data Sets are then also the Selected Data Sets. The following examples, which utilize the FGDIS definition, should help to illustrate use of the WHERE clause:

PRINT STACK SHELL, STACK FLUE LINER WHERE STACK SHELL EXISTS:

In this case, the Qualified Data Sets are the Selected Data Sets. The WHERE clause frequently may contain components that produce Qualified Data Sets that are not the same as, or do not occur at the same level as, Specified Data Sets. If this happens, a level adjustment must be made for each Qualified Data Set that does not belong to the Specified Data Set. The level adjustment will be either upward or downward, depending upon the Specified Data Sets and its relationship to the particular Qualified Data Set being adjusted, but the normalization will always be to the lowest-level element referenced in the Specified Data Sets. A duplicate data set qualification will prevent these lowest-level elements from being output redundantly.

Upward level adjustment takes place when the Qualified Data Set is a descendant (at whatever level) lying below the Specified Data Set according to the hierarchy of the data base definition. The adjustment follows an upward path from the Qualified Data Set to its ancestral data set, the Specified Data Set. If ENTRY or C0 is the Specified Data Set and the Qualified Data Sets lie below level 0, the upward level adjustment selects entire logical entries, and the Selected Data Sets are all level 0 data sets.

PRINT UNIT DATA BOILER - STACK WHERE FUEL TYPE EQ COAL:

In this case, the Qualified Data Sets are one level lower than the Specified Data Sets. The Qualified Data Sets are adjusted upward one level to the Specified Data Set level for retrieval of the Selected Data Sets.

This command will cause not only the qualifying UNIT DATA - BOILER & STACK to print, but also the descendant ACTUAL FUEL DATA associated with each UNIT DATA - BOILER & STACK group because the repeating group name was used as the Specified Data Set (unless the GROUP format option is in effect).

If the Specified Data Sets are named by an element from within a repeating group, the Selected Data Sets will contain the elements specified, and descendants will not be displayed.

Downward level adjustment takes place when the Qualified Data Sets occur at a higher level than the Specified Data Sets, or in other words, when the Qualified Data Set is an ancestor of the Specified Data Set. All paths are followed downward from each Qualified Data Set to all descendant Specified Data Sets, and these become the Selected Data Sets. Downward level adjustment may produce none, one, or many Selected Data Sets from one Qualified Data Set, depending on the number of existing descendants. Again, unless otherwise qualified, all descendants from the Selected Data Sets are output if the Specified Data Sets are named by use of a repeating group.

```
PRINT ACTUAL FUEL DATA WHERE STACK SHELL EQ CONCRETE:
```

When the Qualified Data Set does not belong to the same family repeating group represented by the Specified Data Set, the HAS operator must be used to raise all Qualified Data Sets in the WHERE clause up to the common intersection between the Qualified Data Sets and the disjoint components of the PRINT clause. (See Section 3.3.15 for use of the HAS operator.)

A user who wants to control the level at which qualification takes place may further constrain the WHERE clause statements by use of the HAS operator. The use of HAS actually allows the user to specify the level at which qualification takes place.

The examples given in the above paragraphs have all been relatively simple. Much more complex commands can be structured; when they are, all of the various rules given herein must be observed to obtain the correct result.

Within the restrictions given above, it is possible to structure complex commands containing multiple component names to the left of the WHERE clause, which may or may not reside at the same level in the data base, and the WHERE clause may impose multiple conditions on one or more elements also residing at one or more levels within the data base.

A hypothetical example of an acceptable complex command, which refers to the FGDIS definition, is as follows:

```
PRINT C5,C7,C8,C10,C12 WHERE C15 EXISTS AND C21 GT 100 AND (C207 GT
     10000 OR C213 GT 2.0) AND C215 EXISTS:
```

Restrictions--

(1) The use of a WHERE clause is illegal when unrelated* disjoint elements or repeating groups appear in the object list of the PRINT clause, unless a BY clause is used. (Section 3.3.9)

(2) The WHERE clause may contain up to and including 80 operands, when an operand is an element, repeating group, or a value.

(3) The WHERE clause may contain up to and including 58 operators when an operator includes AND, OR, NOT, left and right parentheses, HAS, AT, EQ, NE, LT, LE, GT, GE, EXISTS, FAILS, SPANS, SAME.

3.3.11 Unary Operators: EXISTS, FAILS

The purpose of the unary operators is to test for the existence or the nonexistence of data values.

Format--

```
...WHERE <element> EXIST, EXISTS, or EXISTING
                   FAIL, FAILS, or FAILING
```

where:

<element> = element name or "C" number

The use of the three forms of EXIST will limit qualification to data sets whose specified element is valued. The use of FAILS limits qualification to the data sets whose specified element has no data value. The use of unary operators within typical commands is quite varied. An example of the use of EXISTS to verify the use of a specific piece of equipment would be:

```
PRINT COMPANY NAME, PLANT NAME WHERE PLANT CITY FAILS:
```

---

* Unrelated disjoint components are defined as those that are not a part of the same repeating group family; e.g., Element 1909, PUMP MANUFACTURER, is a member of the PUMPS repeating group and would be disjoint with Element 1808, TANK TYPE, which is a member of the TANKS repeating group.

Restriction--

(1) A repeating group may not be used as the element to test the existence or nonexistence of data values.

3.3.12 Binary Operators: EQ, NE, LT, LE, GT, GE

The purpose of the binary operators is to define, limit, or bound the range of qualifying data sets.

Format--

...WHERE <element> <binary operator> <specific value>:

where:

<element> = element name or "C" number

<binary operator> =

EQ	equal
NE	not equal
LT	less than
LE	less than or equal to
GT	greater than
GE	greater than or equal to

<specific value> = a value

Binary or relational operators are used within the condition statement of the WHERE clause. The following examples illustrate their use:

...WHERE C213 GE 2.0:

...WHERE C21 GT 100 AND C213 GE 2.0:

...WHERE C22 LT 100 OR C22 GT 200:

3.3.13 Ternary Operators: EQ, NE, SPANS

The purpose of the ternary operators is to qualify data sets on the basis of a range of values.

Format--

...WHERE <element> <ternary operator> <value$_1$>*<value$_2$>:

where:

<element> = element name of "C" number of any data

<ternary operator> = $\begin{bmatrix}\text{EQ}\\\text{SPAN}\\\text{SPANS}\\\text{SPANNING}\end{bmatrix}$ (Equivalent inclusive range discriminators)

or

NE (Exclusive range discriminator)

<value$_1$>*<value$_2$> = literal values where value$_1$ $\leq$ value$_2$, two values separated by the system separator

The ternary operators are quite useful when data sets need to be qualified on the basis of a range of values. When EQ and NE were used to compare elements with a single value, they were being used as binary operators. When used as ternary operators, they compare elements with either an inside or outside range of values. The three forms of SPANS and EQ are equivalents, and they are used as the inclusive range discriminator, e.g.:

...WHERE C21 SPANS 150 * 200:

or

...WHERE C21 EQ 150 * 200:

Both of these hypothetical examples would produce identical results that would test the value range of C21 from 150 to 200, inclusively.

On the other hand, NE is used when an exclusive range discriminator is required, e.g., ...WHERE C21 NE 150*200 would be interpreted as C21 LT 150 or C21 GT 200.

3.3.14 Boolean Operators: AND, OR, NOT

The purpose of the Boolean operators is to indicate the logical relationship between the conditions found in the WHERE clause.

Format--

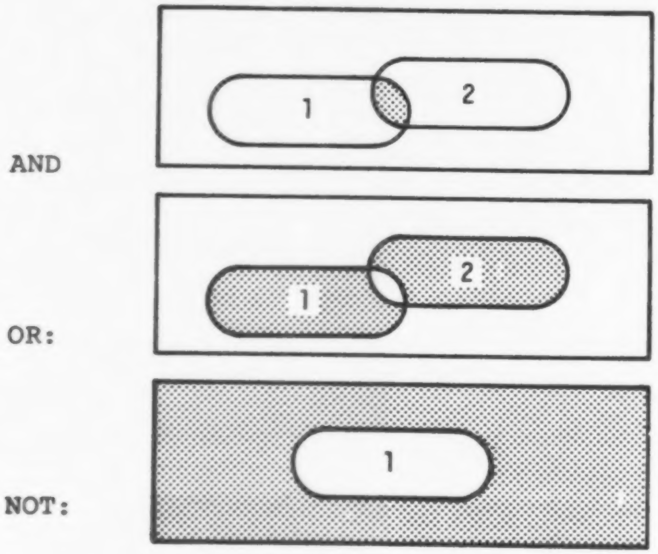
(1) ...WHERE <condition> $\begin{bmatrix}\text{AND}\\\text{OR}\end{bmatrix}$ <condition>...:

(2) ...WHERE <condition>...:

where:

<condition> = any one of the many WHERE clause conditional statements

The Boolean operators AND, OR, and NOT are used to indicate the relationship between the conditions found in the WHERE clause. When AND is used, the data set values eligible for output must satisfy both conditions. When OR is used, the WHERE clause is satisfied by those data sets for which either condition is satisfied. Where NOT is used, the WHERE clause is satisfied by all data sets that do not satisfy a condition. The shaded areas (the area qualifying in each of the diagrams below) illustrate the logic of the three operators:



If the conditions in the WHERE clause related by AND or OR contain components that are not defined to be in the same repeating group family (disjoint data sets), the conditions must include the use of the HAS operator to raise all data sets that satisfy the conditions to at least the level of the first common intersection of the disjoint repeating groups. If the HAS operator is not used with the disjoint data sets, the request will not be processed. (See Section 3.3.15 for use of the HAS operator.)

When the WHERE clause contains only a single Boolean operator, the natural order of Boolean operator processing is not involved. But when Boolean operators are linked together into Boolean combinations, the implicit processing order, without nesting, is first NOT, then AND, and finally OR. The user can further control the WHERE clause qualifications by nesting the operators as in one of the following formats, keeping in mind that statements enclosed by paired parentheses are processed before unnested conditions.

PRINT...WHERE (<condition$_1$> AND <condition$_2$>):

Because no conditions lie outside of the parentheses, they are ignored and the WHERE clause is processed as though the parentheses had been omitted.

PRINT...WHERE NOT (<condition$_1$> AND <condition$_2$>):

Because of nesting, the statement within the parentheses is processed first; all data that meet both <condition$_1$> and <condition$_2$> are selected. The NOT connective causes these data to be excluded.

PRINT...WHERE (<condition$_1$> OR <condition$_2$>) AND (<condition$_3$> AND <condition$_4$>):

First, the OR of (<condition$_1$> OR <condition$_2$>) is found; next, the AND of (<condition$_3$> AND <condition$_4$>) is found, and finally, the AND of these two results is found.

PRINT...WHERE (<condition$_1$> OR <condition$_2$>) AND (NOT (<condition$_3$> AND <condition$_4$>)):

(a) The AND of <condition$_3$> and <condition$_4$> is found; the NOT of that result is then found.

(b) The OR of <condition$_1$> and <condition$_2$> is then found.

(c) The AND of results (a) and (b) is then used for output.

Conditions 3 and 4 are nested two levels deep, whereas conditions 1 and 2 are nested one level deep. The request contains two nestings of conditions.

Restriction--

(1) If either AND or OR are used as WHERE clause operators, and if WHERE clause components related by these operators are not in the same repeating group family (disjoint data sets), the HAS operator must be used to raise all data sets that satisfy the WHERE clause conditions to at least the level of the first common intersection of the disjoint data sets.

3.3.15 HAS Operator

The purpose of the HAS operator is to allow the user to specify the level of data set qualification above the data set level of conditional qualification.

Format--

```
                           ┌        ┐
                           │ HAS    │
...WHERE <repeating group> │ HAVE   │   <condition>:
                           │ HAVING │
                           └        ┘
```

where:

<repeating group> = repeating group name or "C" number

<condition> = any of the WHERE clause conditional statements, nested or unnested

The HAS operator allows qualification of data sets based on the contents of descendant data sets. It allows the user to raise the level of the qualified data sets up to the level of the repeating group specified for the HAS operator. Use of the HAS option increases the user's span of control in selecting data sets to be retrieved or modified. One of the basic structural rules of SYSTEM 2000 is that an element can only assume one value within a data set. If the user wants to retrieve something on the basis that a single element contains "this" value and also "that" value, the HAS clause must be used. A WHERE clause such as ...WHERE C2501 EQ INTERIM AND C2501 EQ FINAL: would be illogical because the Element C2501 can only take on one value in each data set; thus the WHERE clause would be unsatisfied.

The HAS operator, then, makes it possible for the user to qualify a higher level data set based on the fact that it has a value in a descendant data set and a different value for the same element in another descendant set. Therefore, a WHERE clause properly constructed to accomplish the desired results would be as follows:

```
...WHERE C0 HAS C2501 EQ INTERIM AND C0 HAS C2501 EQ FINAL:
```

The system logic associated with the use of the HAS command gives the user the ability to choose the level at which a data set will become a Qualified Data Set. The <repeating group> given to the left of the HAS in a WHERE clause statement actually specifies the data sets that can qualify and become Qualified Data Sets. Thus, the order of processing is as follows: When the condition in a WHERE clause is satisfied, SYSTEM 2000 checks to see if the condition has been modified by a HAS operator. If not, the data set that satisfied the condition becomes a Qualified Data Set. If a HAS operator is present, the data set mentioned on the left side of the HAS becomes the Qualified Data Set.

The use of the HAS operator is mandatory if the user has formed a retrieval request in which the components given in the PRINT clause are not in the same repeating group family as the components given in the WHERE clause conditions. In such a case, the WHERE clause must contain the use of HAS where the repeating group specified for the HAS is the common intersection (or higher intersection) of the components of the PRINT clause and the components of the WHERE clause. For example, because UNIT DATA - BOILER & STACK and FGD SYSTEM are two disassociated repeating groups, the command PRINT BOILER SUPPLIER WHERE NEW/RETROFIT EQ NEW: will produce no output.

```
PRINT BOILER SUPPLIER WHERE C0 HAS NEW/RETROFIT EQ NEW:
```

An alternative method involves a BY clause in the PRINT statement, where the object repeating group of the BY clause represents a data set in the same family as those represented in the WHERE clause:

```
PRINT BY C0, BOILER SUPPLIER WHERE NEW/RETROFIT EQ NEW:
```

The use of HAS is also mandatory if the WHERE clause contains AND or OR operators that join conditions that do not belong to the same repeating group family. The HAS operator must be used to specify the first common intersection (RG) of the disjoint conditions so that all conditions have a common intersection point. By definition, the common intersection may occur at any level. The RG specified for the HAS operator may be the RG at the lowest level of intersection between the two disjoint conditions or it may be a higher level ancestor RG of the common intersection.

If the HAS operator is not used in the above mandatory cases, no output will result.

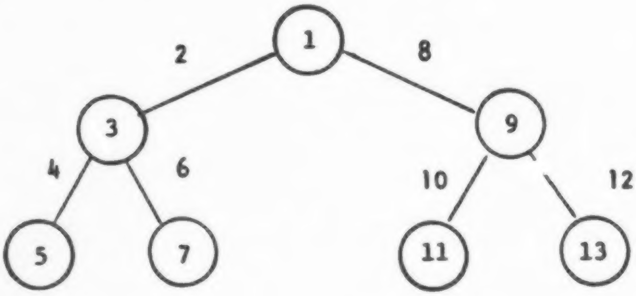
If the repeating group name happens to be plural in the definition, or if proper English dictates, the user may use HAVE instead of HAS; HAVING is also acceptable.

The HAS operator may also be used to handle a multiple nesting problem, should a complex application require such a solution. In the following simulated data base structure (not an unrealistic one), notice the use of HAS associated with the collection of disjoint data sets:

Hypothetical Data Base Definition

```
1* A (NAME)
2* B (RG)
  3* C (NAME IN 2)
  4* D (RG IN 2)
    5* E (NAME IN 4)
  6* F (RG IN 2)
    7* G (NAME IN 6)
8* H (RG)
  9* I (NAME IN 8)
 10* J (RG IN 8)
   11* K (NAME IN 10)
 12* L (RG IN 8)
   13* M (NAME IN 12)
```

If a single data set were constructed for each repeating group represented by the above hypothetical definition, seven data sets would be produced, including the implied one at level zero. Each would be in a horizontal plane disjoint one from the other, as in the following schematic:



Based on this schematic, it is quite obvious that unless a BY clause is used, practically any retrieval or update would require the use of a HAS operator in a qualifying WHERE clause. The following example of a complex WHERE clause is given to stimulate the user in developing his skill in the use of the powerful tool represented by the command verb HAS.

```
PRINT <object list> WHERE ENTRY HAS ((C2 HAS C5 EXISTS AND C2 HAS C7
          EXISTS) AND (C8 HAS C11 EXISTS AND C8 HAS C13 EXISTS)):
```

3.3.16 DITTO Operator

The purpose of the DITTO operator is to copy the action statement of the most recent command.

Format--

(1) `DITTO:`

(2) `DITTO WHERE <conditions exist>:`

where:

<conditions exist> = any of the legal WHERE clause qualification conditions

The DITTO command (which is a convenience, never a requirement) can be used to refer to prior DESCRIBE, TALLY, PRINT, or LIST commands. DITTO is to the <action clause> what SAME is to the <where clause>. If the previous command contained a WHERE clause, then the DITTO command also must contain a WHERE clause.

Example:

```
PRINT C5,C7,C8,C102,C213 WHERE C812 EQ 1:

DITTO WHERE C812 EQ 2:
```

The DITTO operator may be issued with no conjunction following, as in format (1); when so used, the previous command also must not have had a conjunction.

Example:

```
PRINT C1207, C1306:

DITTO:
```

3.3.17 SAME Operator

The purpose of the use of the SAME operator within a WHERE clause is to call and use qualified data sets from a previously used WHERE clause.

Format--

...WHERE SAME:

...WHERE SAME $\begin{bmatrix}\text{AND}\\ \text{OR}\end{bmatrix}$ <conditions exist>:

...WHERE <conditions exist> $\begin{bmatrix}\text{AND}\\ \text{OR}\end{bmatrix}$ SAME...:

...WHERE (<condition_1> $\begin{bmatrix}\text{AND}\\ \text{OR}\end{bmatrix}$ SAME) $\begin{bmatrix}\text{AND}\\ \text{OR}\end{bmatrix}$ <condition_2> $\begin{bmatrix}\text{AND}\\ \text{OR}\end{bmatrix}$ SAME...:

The SAME command also is a convenience, not a requirement. It allows the user to refer to the conditions specified in the previous WHERE clause without having to re-enter the conditions. The two commands that follow would produce the same output because the SAME refers to the conditions of the initial command.

```
PRINT C5,C7,C8 WHERE C201 EQ COAL AND C213 GT 2.0:

PRINT C5,C7,C8 WHERE SAME:
```

The SAME command is simply a direct reference to the last WHERE clause used.

3.4 REPORT WRITER FEATURE

The report writer feature of SYSTEM 2000 enables the user to create formatted reports utilizing data contained within the data base in use. The commands used within the report writer mode, which are straightforward, are presented in the INTEL SYSTEM 2000 manual. For the purposes of the FGDIS, various programs have been developed and stored in a file external to the data base. These programs can be called at any time during the use of the FGDIS for the purpose of generating a report in the format specified by the particular program. Appendix A provides documentation on all the programs available for use. Included in the documentation is a brief abstract as to the function of the program, a sample runstream providing instruction as to the use of the program, sample output the program has created with FGDIS data, and suggested uses and comments. New documentation sheets are made available as new programs are developed. It should be noted that the report writer feature provides great flexibility, and with a few exceptions, most desired formats can be accommodated. Should the need arise for a specific type of output, the user should notify PEDCo personnel so that the proper program can be developed. This is especially important, because a program developed to satisfy the needs of one user may in fact provide assistance for others interested in the same type of information.

The first step in using a report writer program is to issue the following command:

```
@ADD FGDIS.[program name]
```

This command should be issued while in the data base; it will be followed by two dashed lines and the computer prompter (>). At this point, a GENERATE statement should be entered to request report execution.

The format of the GENERATE statement is as follows:

```
GENERATE <program name> {WHERE <where clause>}:
```

where:

<program name> = the name of the program being used (which must correspond to the name used in the step above)

<where clause> = any legal SYSTEM 2000 WHERE clause (Section 3.3.10), except SAME, to determine which sections of the data base are to be selected

Output of the requested report will be preceded by the following message:

```
-SELECTED RG IS n
```

where n is the RG number of the lowest level repeating group common to all families in the report requested by the GENERATE command.

SECTION 4

OUTPUT CONTROL

4.1 NCC BIN ASSIGNMENTS

Sometimes it may be desirable to direct lengthy output to a high-speed printer at NCC rather than tying up the low-speed terminal being used. This can be accomplished by directing output to a user-specified file, which is then printed at NCC. The output from the run will be placed in the bin corresponding to the bin number in the @RUN statement and will subsequently be mailed to the address associated with the respective bin, where it can be picked up. This is why a two-digit bin number is a necessary part of the RUNID that is included in the @RUN statement. The bin number should correspond to the location to which a user would like to have output mailed. For EPA personnel, this number can be determined from Table 4, which provides the bin numbers and associated addresses of the EPA regional offices. Non-EPA users can contact Data Processing Support services at (919) 541-2385 for a bin assignment. As previously specified, the bin number is always included in the @RUN statement, whether lengthy output is anticipated or not.

4.2 DIRECTING OUTPUT TO NCC BINS FOR MAILING

The procedures for directing output to an NCC bin rather than to the terminal being used is fairly simple and is an invaluable time saver when large jobs are to be run. The following procedure (which assumes that the user is in the FGDIS when the decision is made to re-route the output of the next command) should be used:

(1) While in the data base, type the following:

```
EXIT:
```

which will terminate use of the data base but continue the session on the UNIVAC.

TABLE 4. REGIONAL OFFICE BIN NUMBER ASSIGNMENTS

Region	Bin	Address	Phone
0	80	EPA Room 308E 26W - St. Claire Street Cincinnati, Ohio 45268	(513)684-7780
1	81	EPA - Region 1 JFK Federal Building Room 2207 Boston, Massachusetts 02203	(617)223-5885
2	82	EPA - Region 2 26 Federal Plaza Room 404 New York, New York 10278	(212)264-9578 (212)264-9850
3	83	EPA - Region 3 6th & Walnut Streets Philadelphia, Pennsylvania 19106	(215)597-3530
4	84	EPA - Region 4 345 Courtland Street Atlanta, Georgia 30308	(404)257-3286
5	85	EPA - Region 5 230 South Dearborn Avenue Chicago, Illinois 60604	(312)353-2303 (312)353-2205 (312)353-2205 (312)886-6226
6	86	EPA - Region 6 1201 Elm Street First International Building Dallas, Texas 75270	(214)729-2641
7	87	EPA - Region 7 25 Funston Road Kansas City, Missouri 66115	(816)758-4285
8	88	EPA - Region 8 1860 Lincoln Street Denver, Colorado 80203	(303)327-2226
9	89	EPA - Region 9 215 Fremont Street San Francisco, California 94111	(415)454-8208 (415)454-8222
10	90	EPA - Region 10 1200 Sixth Avenue Seattle, Washington 98101	(206)399-1580

(2) The normal response to the above command will be:

```
DATE-----TIME-----END SYSTEM 2000
Release 2.90A
```

(3) After receipt of the computer prompter (>), type:

```
@ASG,UP [user's initials].
```

The [user's initials] are simply the two or three initials of the user followed by a period. The normal response to this will be:

```
READY
```

(4) After receipt of the computer prompter (>), re-initiate use of the data base by typing:

```
@ADD FGDIS.RUN
```

This will again put the user back in the FGDIS, which will be signified by the normal execution messages.

(5) After the data base prompter has been received, type the following:

```
REPORT FILE IS [user's initials]:
```

The [user's initials] must correspond to those used in Step 3. This step directs all output to the alternate file.

(6) Another data base prompter will be received, at which time the normal data base command can be entered. Remember that no output will come to the terminal; it will go to the specified file.

(7) When generation of the output is complete, the data base prompter will again be printed. At this time, type:

```
REPORT FILE IS OUTPUT:
```

This redirects output to the terminal being used.

(8) Upon receipt of the next prompter, exit the data base by typing:

```
EXIT:
```

(9) When the normal data base termination messages have been received and a prompter has printed, type:

```
@FREE [USER'S INITIALS].
```

Followed by (after receipt of the prompter):

```
@SYMΔ[USER'S INITIALS].,,PR1100
```

The [user's initials] must correspond exactly to those used in Steps 3 and 5. This instructs the file to be printed at NCC, and output will be placed in the bin corresponding to the number that was used in the RUNID of the @RUN statement.

(10) After the above command is executed, a prompter will again be received, at which time the user may log-off the computer by using the normal log-off procedure (Section 3.1.2) or re-access the data base by using the normal access command (Section 3.2).

The output generated by use of the above sequence of commands will be mailed to the address associated with the bin number used. If a special mailing address is desired for a specific job, or if assistance is needed on a job that is to be printed at NCC, notify Production Control at (919) 541-3655 or FTS at 629-3655.

II. FGDIS TERMINOLOGY

SECTION 5

BASIC SCRUBBER/ABSORBER TYPES

The basic scrubber/absorber types (Table 5) identify the various gas/liquid contacting devices which are used commercially to collect particulate and SO_2 from utility coal-fired boiler flue gases. Included in this classification are wet scrubbers, absorbers, and spray dryers. Excluded are such devices as adsorbers, catalyst towers, oxidation towers, etc.

The generic and specific scrubber/absorber classifications which are described in the following represent a compilation of information sources provided by the industry, industry trade associations, and equipment suppliers and designers. This information was updated and expanded in accordance with the design data contained in the flue gas desulfurization information system (FGDIS) for coal-fired utility boilers equipped with particle scrubbers and FGD systems.

5.1 GENERIC AND SPECIFIC CLASSIFICATIONS

Table 5 contains the generic and specific classifications developed to identify the scrubber/absorber types contained in FGDIS. Table 5 also provides trade names or common names which have been assigned to special or proprietary scrubber/absorber designs.

5.1.1 Scrubber/Absorber Classification Descriptions

Venturi Tower--

In the venturi tower, scrubbing liquor is introduced at the inlet of the converging section of the venturi and flows down the walls of this section. The entering gas stream is accelerated in this converging venturi section. At the entrance to the venturi throat, the scrubbing liquor is sheared into fine droplets by the high velocity gas stream. In the turbulent zone just

TABLE 5. BASIC SCRUBBER/ABSORBER TYPES

Generic type	Specific type	Trade or common name/ design
Venturi tower	Fixed throat	
	Fixed throat/cyclonic separator	
	Variable-throat/top-entry plumb bob	
	Variable-throat/bottom-entry plumb bob	Dual-throat variable scrubber
	Variable-throat bottom-entry liquid distribution disc	Flooded disc scrubber
	Variable-throat/side-movable blades	
	Variable-throat/side-movable blocks	
	Variable-throat/vertically-adjustable rod decks	Rod scrubber
	Variable-throat/adjustable drum	Radial flow venturi
Spray tower	Open countercurrent spray	
	Open crosscurrent spray	Horizontal spray chamber
	Open cocurrent spray	Cocurrent scrubber
Tray tower	Sieve tray	
	Valve tray	Bubble cap tray tower
Packed tower	Fixed bed packing	
	Static bed packing	Marble-bed scrubber
	Mobile bed packing	Turbulent contact absorber
		Polysphere scrubber
	Entrained packing	Mobile bed contactor
	Rod deck	Ventri-sorber
	Grid packing	
Impingement tower	Fixed baffle	Disc contactor
Mechanically-aided tower	Gas sparger	Jet bubbler reactor
Combination tower	Spray/packed	
	Venturi/spray	
Spray dryer	Cocurrent Countercurrent Mixed flow }	Hydraulic pressure nozzle (single fluid) Hydraulic pressure nozzle (two-fluid)
	Crossflow	Rotary atomizer

after the entrance to the throat, there are large velocity differences between the atomized liquid droplets and the gas stream. The considerably higher velocity of the gas stream causes particle impaction and/or gas absorption on the liquor droplets. As the liquor droplets and gas decelerate through the divergent section of the venturi, the droplets collide with each other to form larger droplets and a portion of the energy required to accelerate the gas through the venturi throat is recovered.

In a fixed-throat venturi, the venturi throat opening remains constant (Figure 2a). However, a number of variable-throat designs are used to vary the opening of the venturi-throat opening to accommodate varying gas flows. Such designs include a movable plumb bob (Figures 2b and c), a movable liquid distribution disk (Figure 2d), side-movable plates or blades (Figure 2e) and blocks (Figure 2f), vertically-adjustable rod decks (Figure 2g), and a movable drum (Figure 2h).

Venturi towers are considered high energy devices because they normally operate in a 10 to 80 in. H_2O pressure drop range. As such, they are capable of removing fine particulate with increasing removal effectiveness in direct proportion to increased pressure drop. They are also somewhat effective contacting devices for gas absorption because of the large liquid surface area provided to the gas stream by the finely atomized scrubbing liquor.

The gas and droplets discharging from the venturi can either make a 90° turn and pass through a cyclonic separator for removal of entrained droplets (Figure 2i), or make a 180° turn where a majority of the droplets are collected in a sump prior to passage through a mist eliminator (Figure 2c).

Spray Tower--

In spray towers, scrubbing liquor is introduced into the gas stream from atomizing nozzles. The relative velocity between the gas stream and the liquor spray results in impaction of particulate on the liquid droplets and/or intimate contact for gas absorption. The pressure imparted to the scrubbing liquor discharged from the spray nozzles combined with the velocity of the incoming gas stream produces liquid droplets from 50 to 4000 microns in diameter. Low gas-side pressure drops (typically 1 to 4 in. H_2O) are encountered because of the lack of tower internals.

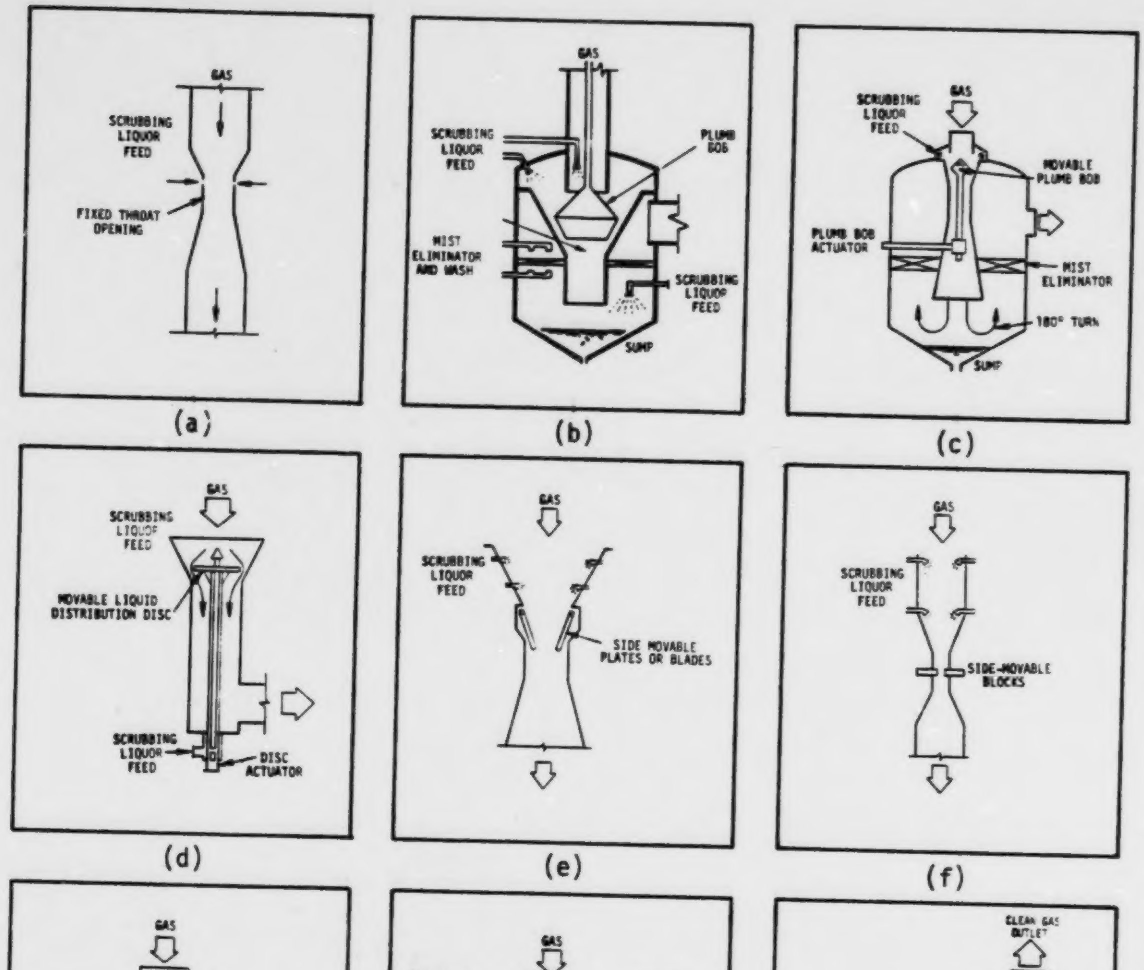

GAS
SCRUBBING LIQUOR FEED
FIXED THROAT OPENING
(a)
GAS
SCRUBBING LIQUOR FEED
PLUMB BOB
MIST ELIMINATOR AND WASH
SCRUBBING LIQUOR FEED
SUMP
(b)
GAS
SCRUBBING LIQUOR FEED
MOVABLE PLUMB BOB
PLUMB BOB ACTUATOR
MIST ELIMINATOR
180° TURN
SUMP
(c)
GAS
SCRUBBING LIQUOR FEED
MOVABLE LIQUID DISTRIBUTION DISC
SCRUBBING LIQUOR FEED
DISC ACTUATOR
(d)
GAS
SCRUBBING LIQUOR FEED
SIDE MOVABLE PLATES OR BLADES
(e)
GAS
SCRUBBING LIQUOR FEED
SIDE-MOVABLE BLOCKS
(f)
GAS
ROD-DECKS
VENTURI SECTION
(g)
GAS
SCRUBBING LIQUOR FEED
SCRUBBING LIQUOR FEED
MOVABLE DRUM
MIST ELIMINATOR
DRUM ACTUATOR
LIQUID OUTLET
(h)
CLEAN GAS OUTLET
GAS
SCRUBBING LIQUOR FEED
CYCLONIC SEPARATOR
FLOODED ELBOW
TANGENTIAL INLET
(i)

Figure 2. Venturi tower configurations included in FGDIS: (a) fixed-throat; (b) variable-throat top-entry plumb bob; (c) variable-throat bottom-entry plumb bob; (d) variable-throat bottom entry liquid distribution disc; (e) variable-throat side-variable plates or blades; (f) variable-throat side-movable blocks; (g) variable-throat vertically-adjustable rod decks; (h) variable-throat adjustable-drum; (i) fixed-throat cyclonic separator.

The open countercurrent spray tower is a simple configuration in which the gas stream passes vertically upward through the tower with the liquid droplets falling by gravity countercurrent to the gas flow (Figure 3a). Variations of this design configuration include the open crosscurrent spray tower (Figure 3b) and the open cocurrent spray tower (Figure 3c). In the former, the gas stream passes horizontally through the vessel with the liquid droplets falling by gravity; in the latter, the gas stream and droplets travel in the same direction downward through the tower.

Tray Tower--

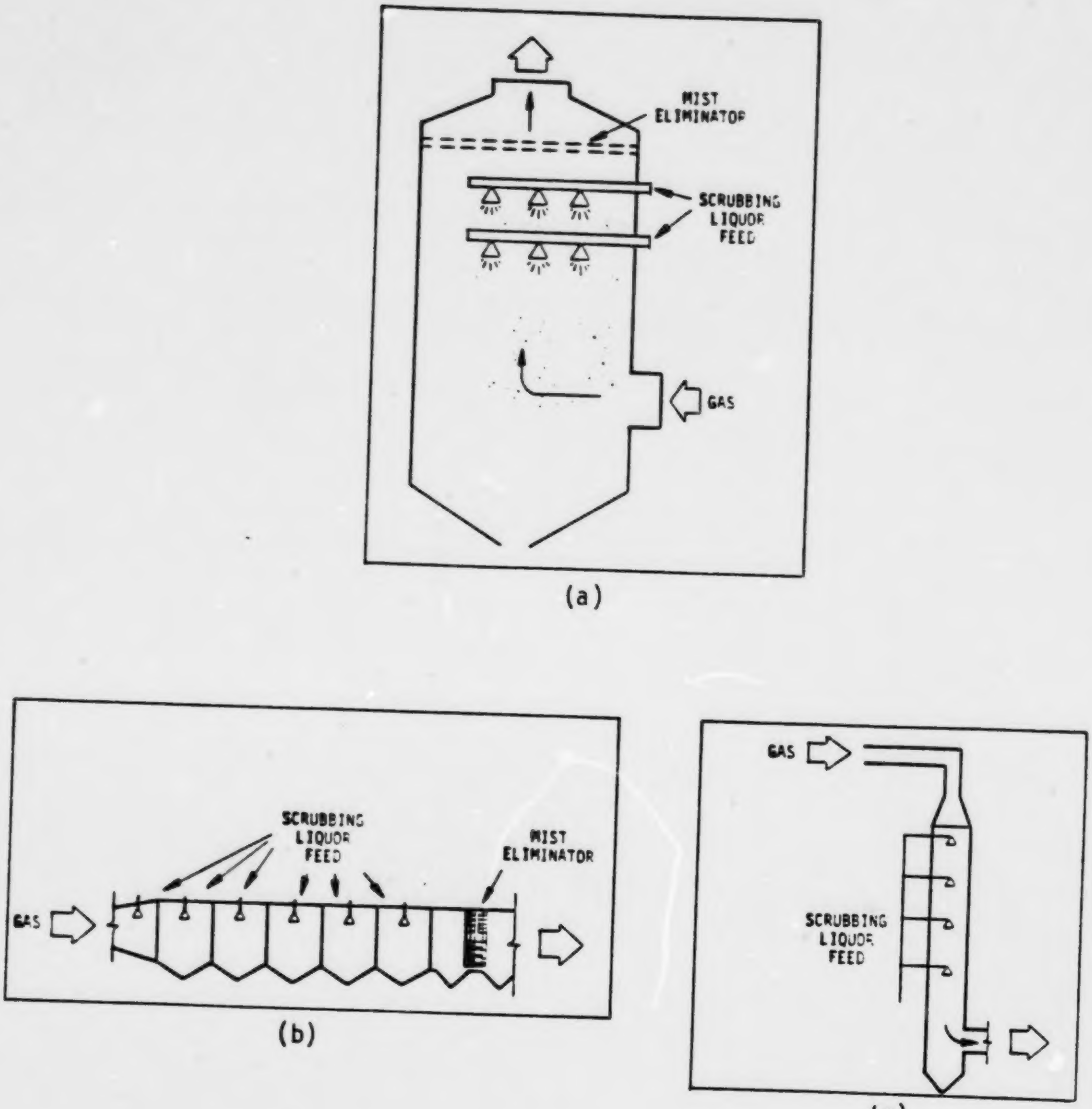
In tray towers, the gas stream enters the base of the tower and passes upward through one or more trays containing openings. Scrubbing liquor is introduced onto the top and flows across it and down across each preceding tray (Figure 4).

In a conventional sieve tray tower, gas velocities are used such that the gas passing up through the hole bubbles through the liquid on the tray providing intimate gas/liquid contact (Figure 4). In a valve tray tower, the tray level consists of a bed of "bubble caps" each surmounted by a constraining spider cage (Figure 4). The gas flows upward through the caps and the liquid which flows across the tray is kept in a state of constant froth by the gas which exits each cap at venturi velocity.

Packed Tower--

In packed towers, the gas enters the base of the tower and passes up through the packing countercurrent to the scrubbing liquor introduced at the top of the tower (Figure 5). The packing can be of a variety of different shapes and configurations. In can also be stationary or mobile. The purpose of the packing is to provide a large surface area for intimate gas/ liquid contact.

Fixed bed consists of a rigid, stationary packing such as a "honeycombed" material (Figure 5a). Static bed consists of a largely immobile bed of packing, such as glass spheres (Figure 5b). Mobile bed packing consists of a highly mobile bed of solid spheres which is fluidized by the gas stream (Figure 5c). Entrained bed packing consists of a mobile bed of solid spheres which are entrained in the gas stream, passed through the tower, and disengaged for recycling (Figure 5d). Rod decks and grids, (Figures 5e and f)


MIST ELIMINATOR
SCRUBBING LIQUOR FEED
GAS
SCRUBBING LIQUOR FEED
MIST ELIMINATOR
GAS
GAS
SCRUBBING LIQUOR FEED

(a)

(b)

(c)

Figure 3. Spray tower types included in FGDIS:
(a) open countercurrent; (b) open crosscurrent; (c) open cocurrent.

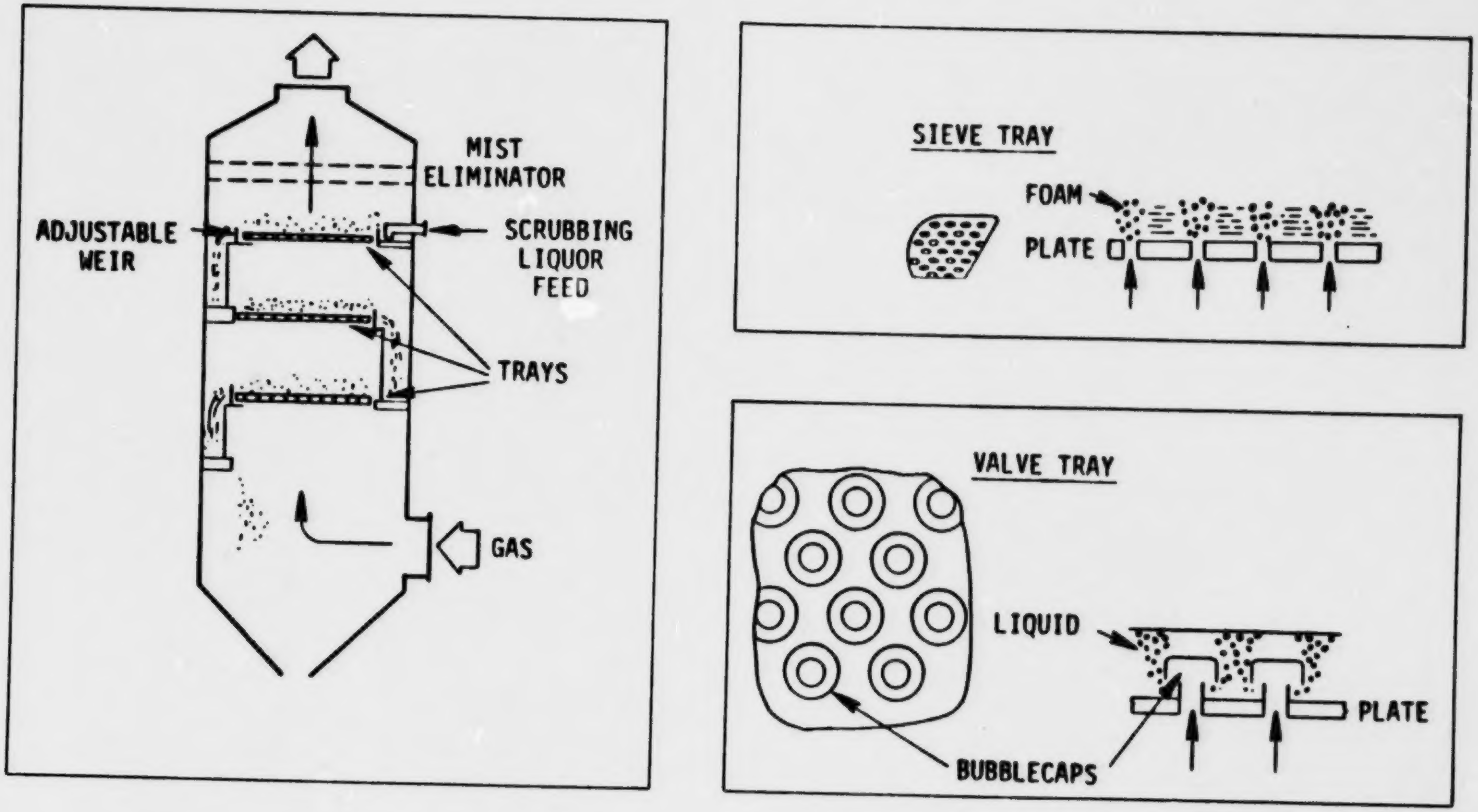

MIST
ELIMINATOR
ADJUSTABLE
WEIR
SCRUBBING
LIQUOR
FEED
TRAYS
GAS
SIEVE TRAY
FOAM
PLATE
VALVE TRAY
LIQUID
PLATE
BUBBLECAPS

Figure 4. Tray tower and tray types.

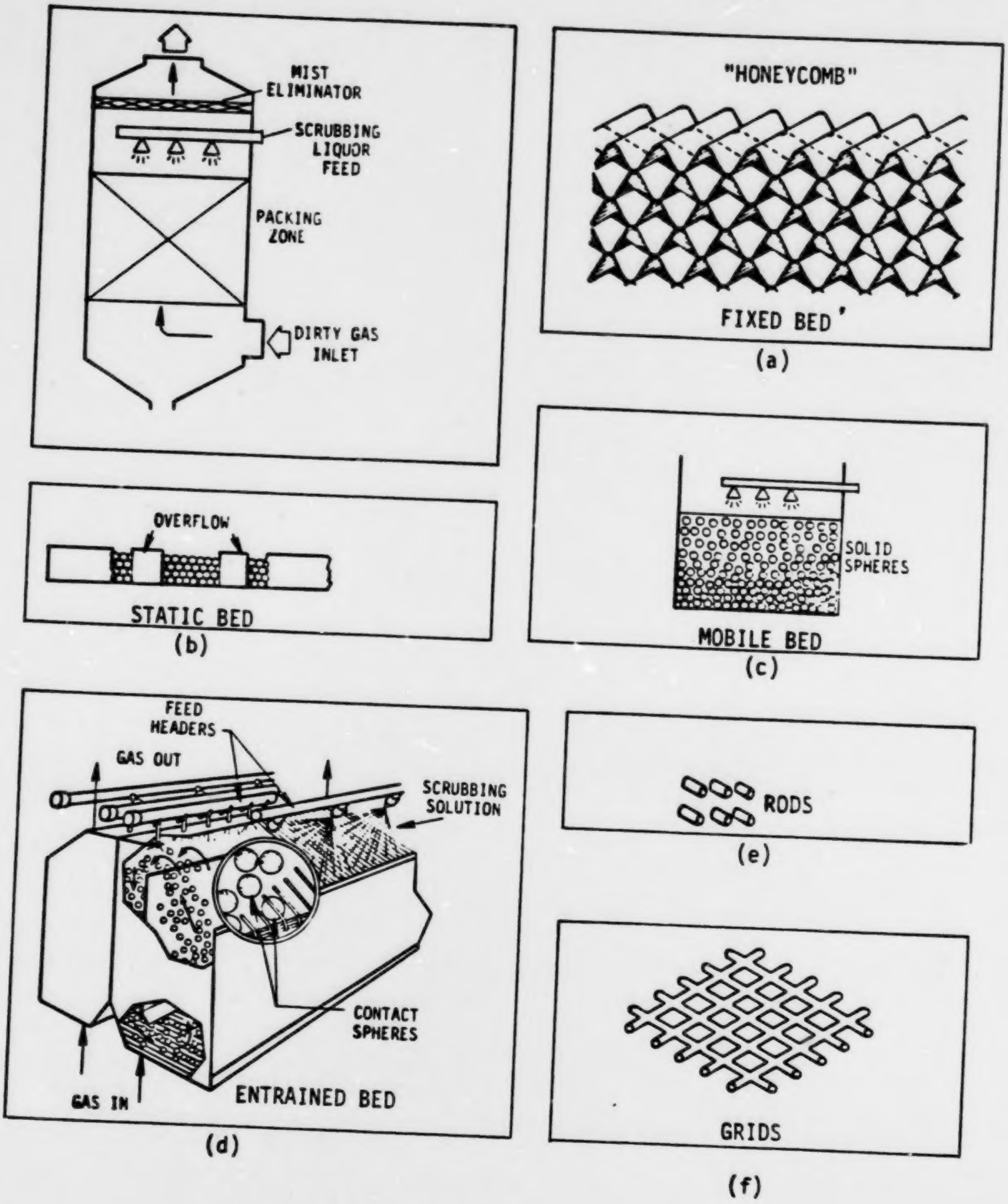

MIST ELIMINATOR
SCRUBBING LIQUOR FEED
PACKING ZONE
DIRTY GAS INLET
"HONEYCOMB"
FIXED BED
(a)
OVERFLOW
STATIC BED
(b)
SOLID SPHERES
MOBILE BED
(c)
FEED HEADERS
GAS OUT
SCRUBBING SOLUTION
CONTACT SPHERES
GAS IN
ENTRAINED BED
(d)
RODS
(e)
GRIDS
(f)

Figure 5. Packed tower and packing types.

represent internals which can be used in lieu of packing and still provide a sufficiently large surface area for intimate gas/ liquid contact.

Impingement Towers--

In impingement towers, the gas stream enters the tower where it is contacted with scrubbing liquor. The gas stream is then accelerated to a higher velocity and changed in direction by a fixed baffle, disk, or vane. The liquid droplets coalesce on the baffles or vanes and then drain to the sump or effluent hold tank. Solid particles (particulate or scrubbing slurry) which may accumulate on the baffles or vanes are washed off by intermittent or continuous sprays. The baffles and vanes represent impingement "targets" which provide acceleration and direction changes to promote intimate gas/ liquid contact. Figure 6 shows a disk contactor type impingement tower with cascading baffle disks and rings.

Mechanically-Aided Towers--

In mechanically-aided towers, gas/liquid contact is aided by a mechanical devices such as a gas sparger. In the gas sparger design (Figure 7), an array of vertical spargers have their open ends submerged 4 to 16 inches below the liquid surface. The high gas velocity created by introducing the gas into the scrubbing liquor via the spargers entrains the surrounding liquid, creating a froth layer with a large gas/liquid interfacial area.

Combination Tower--

In combination towers, two or more separate tower design features, which were described in the foregoing, are incorporated into one tower for operation as an integral unit. These combined designs provide flexibility because extreme operating conditions and/or selective removal capabilities can be segregated into discrete areas of the tower, thus permitting separate chemical and physical conditions to be maintained. Designs which have been developed for commercial application to date include a spray/packed tower (open, countercurrent, spray/fixed-bed packing), and a venturi/spray tower (variable-throat, top-entry, plumb bob venturi/spray tower).

Numerous combination towers other than those described in the foregoing have been contrived and tested. They are not discussed here due to either their lack of commercial development or their essentially geometric variation of a tower design previously described.

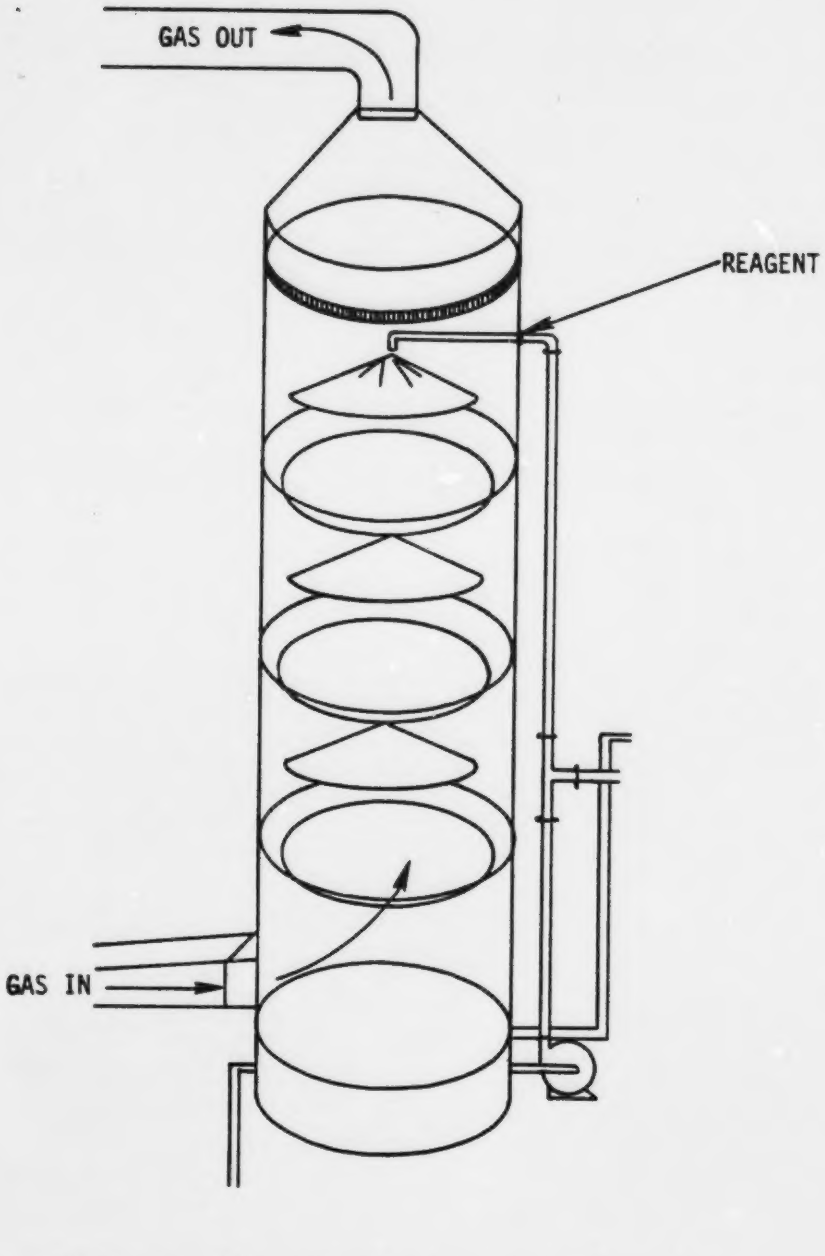

GAS OUT
REAGENT
GAS IN

Figure 6. Disc contactor type impingement tower with cascading baffle disks and rings.

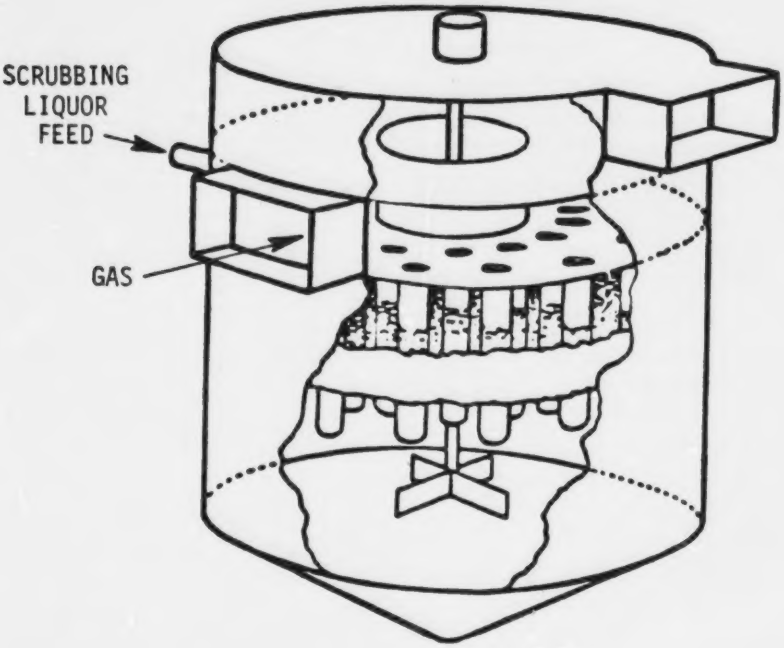

SCRUBBING LIQUOR FEED
GAS

Figure 7. Mechanically-aided gas sparger tower.

Spray Dryers--

Spray drying is the transformation of a pumpable fluid feed (solution or slurry) into a dried particulate product in a single drying process. The feed is atomized and contacted with hot gas. Rapid evaporation occurs due to the extensive surface area provided by the spray. Following the atomization and gas contact stages, a dry product is formed, and this product is recovered and separated from the drying gas.

With respect to FGD technology, spray dryers are defined as any apparatus in which flue gas is contacted with a liquor or slurry such that the flue gas is adiabatically humidified to within some approach of saturation and the liquor or slurry is evaporated to apparent dryness. The SO_2 absorbent in spray dryers may be dispersed by rotary atomizers or hydraulic pressure nozzles. In spray dryer systems, boiler flue gas is passed through a spray dryer where it reacts with a mist of dilute sodium liquor or calcium-based slurry. Immediate chemical reaction removes the SO_2 from the flue gas, and the sensible heat of the flue gas evaporates the water and dries the solution to form a dry powder. The flue gas never reaches saturation. The dry powder and fly ash are collected as a dry product downstream of the dryer in an ESP or fabric filter.

Four basic types of spray dryers are available for use in FGD systems. These basic spray dryer configurations are differentiated according to method of atomization and how the liquor or slurry feed is initially contacted with the gas. These four basic types are cocurrent, countercurrent, crossflow, and mixed flow (Figure 8). The cocurrent design represents a plug flow reactor combined with nozzle (hydraulic pressure or two-fluid) atomization with the flue gas and feed introduced into the spray dryer in the same direction. The countercurrent design represents a variant of the cocurrent design that the flue gas and feed are introduced in the spray dryer in an opposing fashion. The crossflow design provides a crossflow spray pattern combined with rotary (wheel) atomization in a backmixed reactor. The mixed flow design is a variant of the crossflow design in that the feed is introduced via nozzle atomization in either a "fountain" from below or a top-entry fashion.

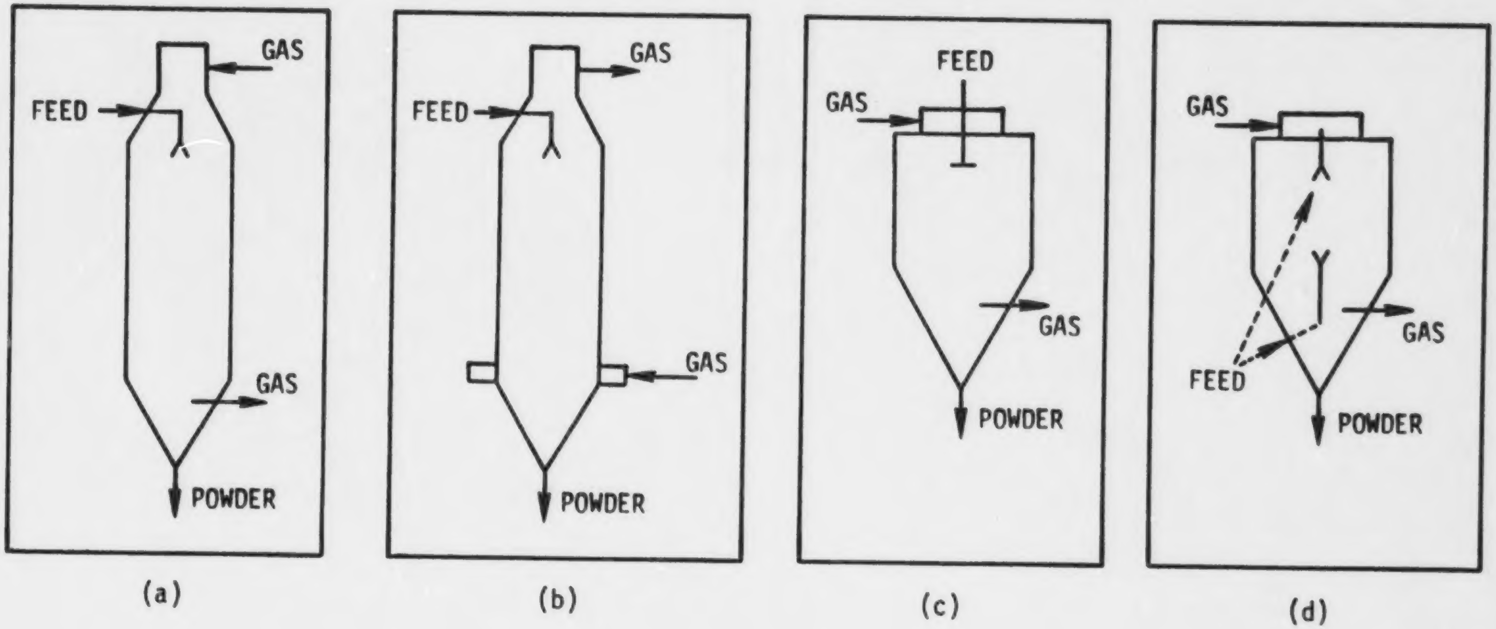

FEED
GAS
GAS
POWDER
(a)
FEED
GAS
GAS
POWDER
(b)
FEED
GAS
GAS
POWDER
(c)
GAS
FEED
GAS
POWDER
(d)

Figure 8. Four basic spray dryer types:
(a) cocurrent; (b) countercurrent; (c) cross flow; (d) mixed flow.

SECTION 6

BASIC MIST ELIMINATOR TYPES

A mist eliminator is that part of a scrubber/absorber designed to remove entrained liquid droplets from a gas stream by centrifugal action, impingement on internal surfaces of the scrubber, or on a bed of packing, mesh, or baffles located at or near the scrubber gas outlet.

6.1 GENERIC AND SPECIFIC CLASSIFICATIONS

There are two basic types of mist eliminator categories used in FGD systems: the precollector and the primary collector. A precollector precedes the primary collector and is designed to remove most of the large entrained mist droplets from the gas stream before it passes through the primary collector. FGD systems may be equipped solely with primary collectors. A primary collector sees the heaviest duty with respect to mist loading and required removal efficiency.

Table 6 summarizes the various designs for precollectors and primary collectors used or planned for use in commercial-scale FGD systems for coal-fired utility boilers. The designs are categorized by generic, specific, and common or trade name classifications. The generic classification designates the basic collection mechanism by which the entrained mist droplets are removed from the gas stream. The specific classification includes distinct design variations within each generic grouping. The common or trade name classification lists trade names or common names assigned to special or proprietary designs. This classification also includes variations of specific design types.

Precollectors are of the bulk separation or knock-out type. Primary collectors may be of the impingement, centrifugal or cyclonic generic types.

TABLE 6. BASIC MIST ELIMINATOR TYPES

Generic type	Specific type	Trade or common name
Precollectors		
Bulk separation	Baffle slats	Bulk entrainment separator
	Perforated trays	Sieve tray
	Gas direction change	90° 180°
Knock-out	Wash tray	Valve [bubble cap] tray
	Trap-out tray	Irrigation tray
Primary collectors		
Impingement	Mesh	Knitted wire mesh pad
	Curved deflector plate	Gull wing
	Baffle	Open vane [slat] Closed vane
	Tube bank	Vertical parallel tubes
Centrifugal	Radial vane	Radial baffle Spin vane
Cyclonic	Cyclonic separator	Cyclonic tower

6.1.1 Precollector Mist Eliminator Classification Descriptions

Bulk separators and knock-out devices are designed to remove the majority of large entrained liquid and solid particles from the gas stream prior to passing through the primary collector mist eliminator. In some cases the devices are designed to also allow the continuous recirculation of mist eliminator wash water.

Bulk Separation--

Bulk separation is effected by baffle slats, perforated trays, or a gas direction change (90° to 180°) (Figure 9). Bulk separation devices are characterized by a low potential for solids deposition, a low gas-side pressure drop, and simplicity. Entrained solids and droplets of moisture drop out of the gas stream because the mass of these particles is substantially greater than that of the gas molecules in the stream. Consequently, these larger molecules are unable to round the bends the gas stream makes and they are captured by and drain down the wet walls of the chamber or fall directly to the base of the chamber.

Knock-out--

Like bulk separators, knock-out devices serve to remove large solid and liquid particles. Unlike bulk separators, however, knock-out devices provide a means to recycle the mist eliminator wash water. By recirculating the relatively clean wash water, several advantages are possible. First, the wash water flow rate can be significantly increased, and second, the system allows greater flexibility in washing operations, wash water treatment, addition of scaling inhibitors, etc. These devices are not used at most installations primarily because of plugging, high pressure drop (≥ 3 in. H_2O), increased complexity, and operational problems. Undersprays are often necessary to protect the knock-out devices from plugging.

Knock-out type precollectors used in conventional FGD systems are of either the wash tray or trap-out tray design (Figure 10a and 10b).

6.1.2 Primary Collector Mist Eliminator Classification Descriptions

Impingement--

Impingement (or inertial impaction) effects mist removal by collection on surfaces placed in the gas streams. The liquid droplets thus collected

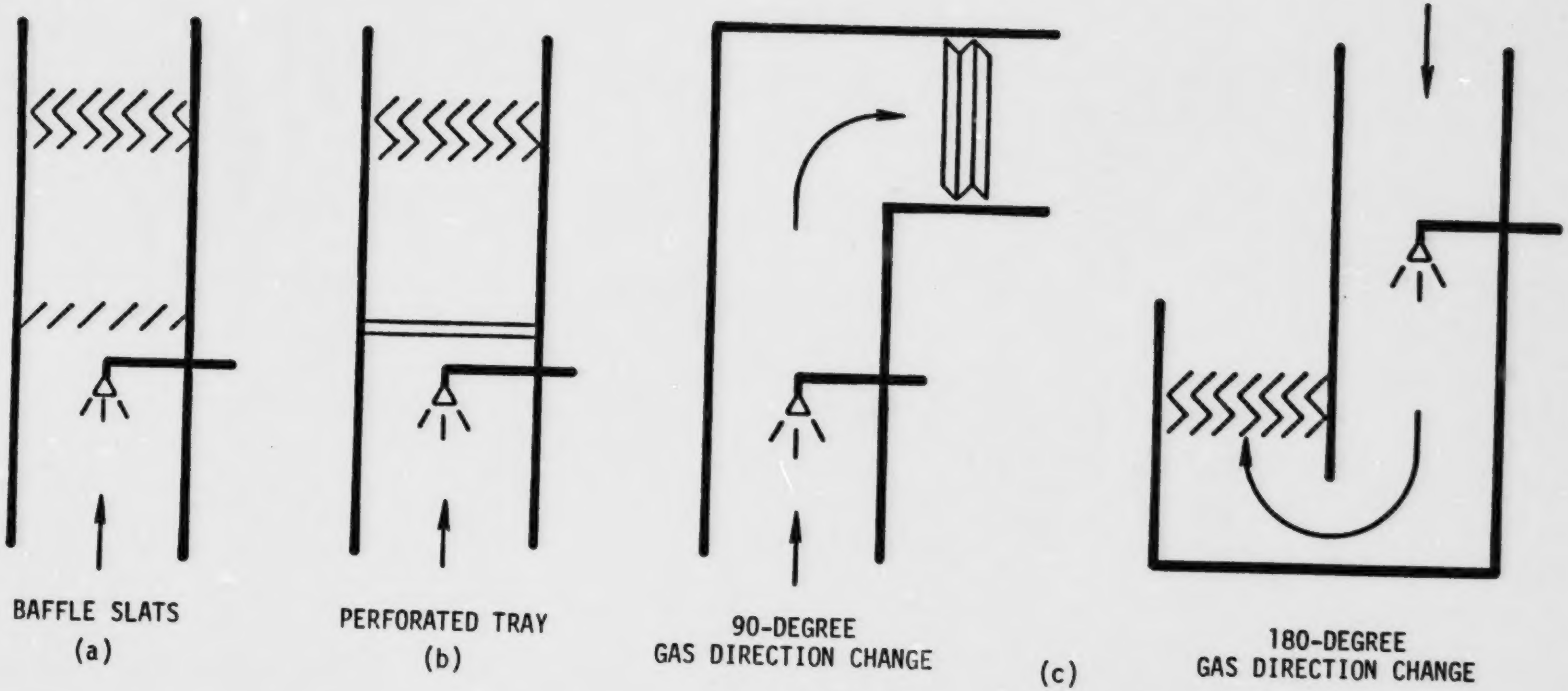

BAFFLE SLATS
(a)
PERFORATED TRAY
(b)
90-DEGREE
GAS DIRECTION CHANGE
(c)
180-DEGREE
GAS DIRECTION CHANGE

Figure 9. Four bulk separation type precollectors followed by a conventional primary collector (chevron type mist eliminator).

(a) Baffle slots; (b) perforated tray; (c) gas direction change.

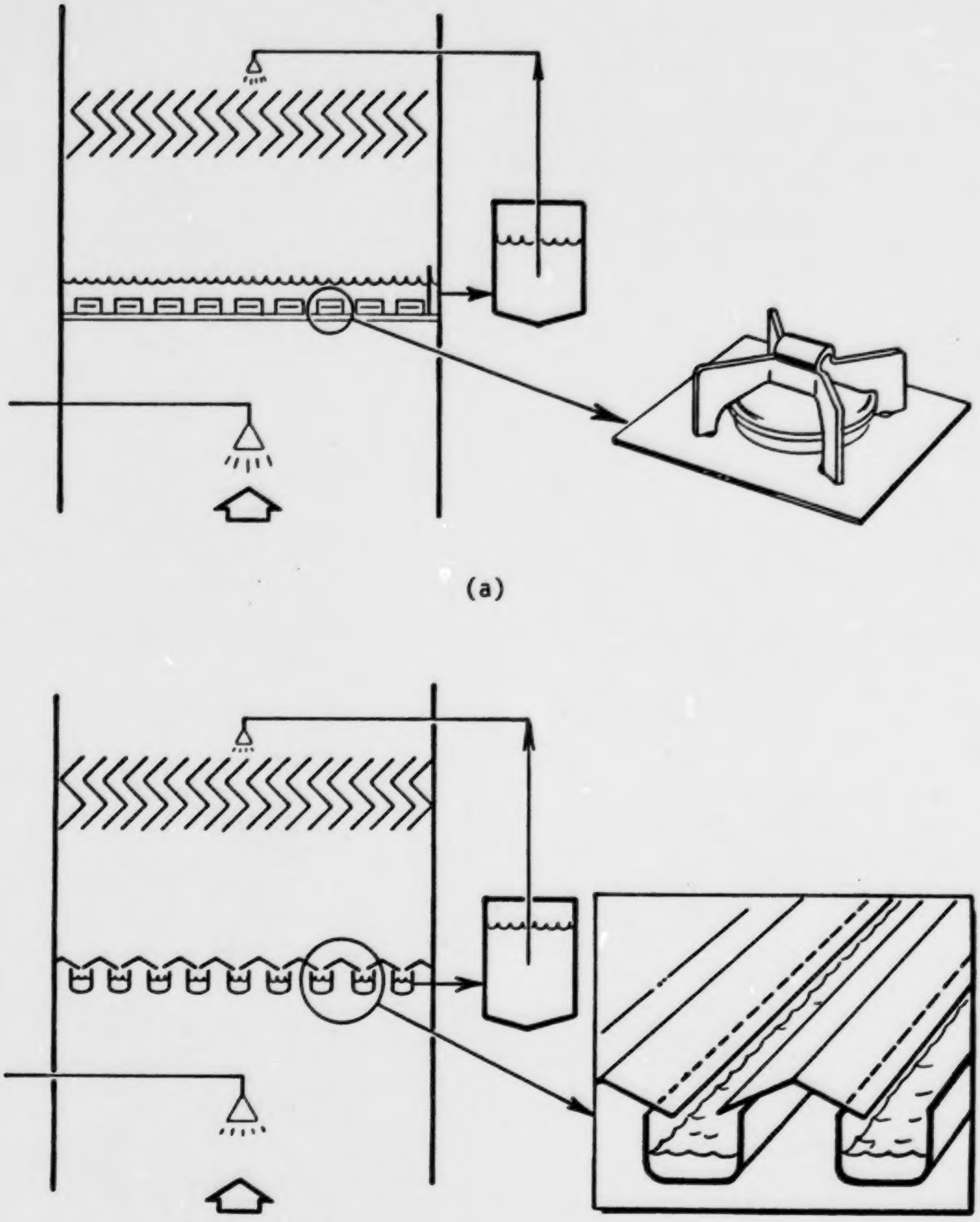


Figure 10. Knock-out precollectors included in FGDIS:
(a) wash tray (valve tray); (b) trap-out tray (irrigation tray).

coalesce and fall by gravity back into the scrubbing liquor. Impingement type mist eliminators include mesh, tube bank, curved deflector plate, and baffle configurations. Examples of these are shown in Figure 11.

Baffle type mist eliminators include the conventional open vane (slat) and closed vane chevron designs. The baffle design mist eliminators are most common and constitute the simplest method of mist elimination. Entrained mist is collected in such devices as the gas is forced to make abrupt changes in flow direction as it passes through a series of slats (may be continuous or discontinuous).

Centrifugal Separation--

Centrifugal separation is based on the use of baffles that impart a centrifugal force on the gas (Figures 12a and 12b). The heavier mist droplets entrained in the gas are collected on the wall surface of the chamber as the gas path is continuously redirected into a circle pattern. The formerly entrained material drains down the walls by gravity back to the scrubbing liquor.

There are two types of centrifugal separation mist eliminators: the radial baffle and the spin vane. The radial baffle utilizes geometrically curved vanes to redirect the gas stream from the vertical into a horizontal, spinning flow, directed towards the vessel wall. The heavier liquid and solid particles in the mist are first accelerated (via the cross-sectional-area reduction) and then directed to collide, adhere, and be collected on the vessel walls. In the spin vane mist eliminator the gas stream is directed down and outward towards the vessel walls by a nose-cone-shaped obstacle encircled by vanes that spin the gas against the duct wall where the liquid and solid particles collide and are collected.

Cyclonic Separation--

Cyclonic separation involves the use of tangential inlets which impart a swirl or cyclonic action to the gas as it passes through the separator chamber (Figure 13). The mist droplets are captured in the same way as with the centrifugal separator. The formerly entrained material drains down the walls by gravity back to the scrubbing liquor.

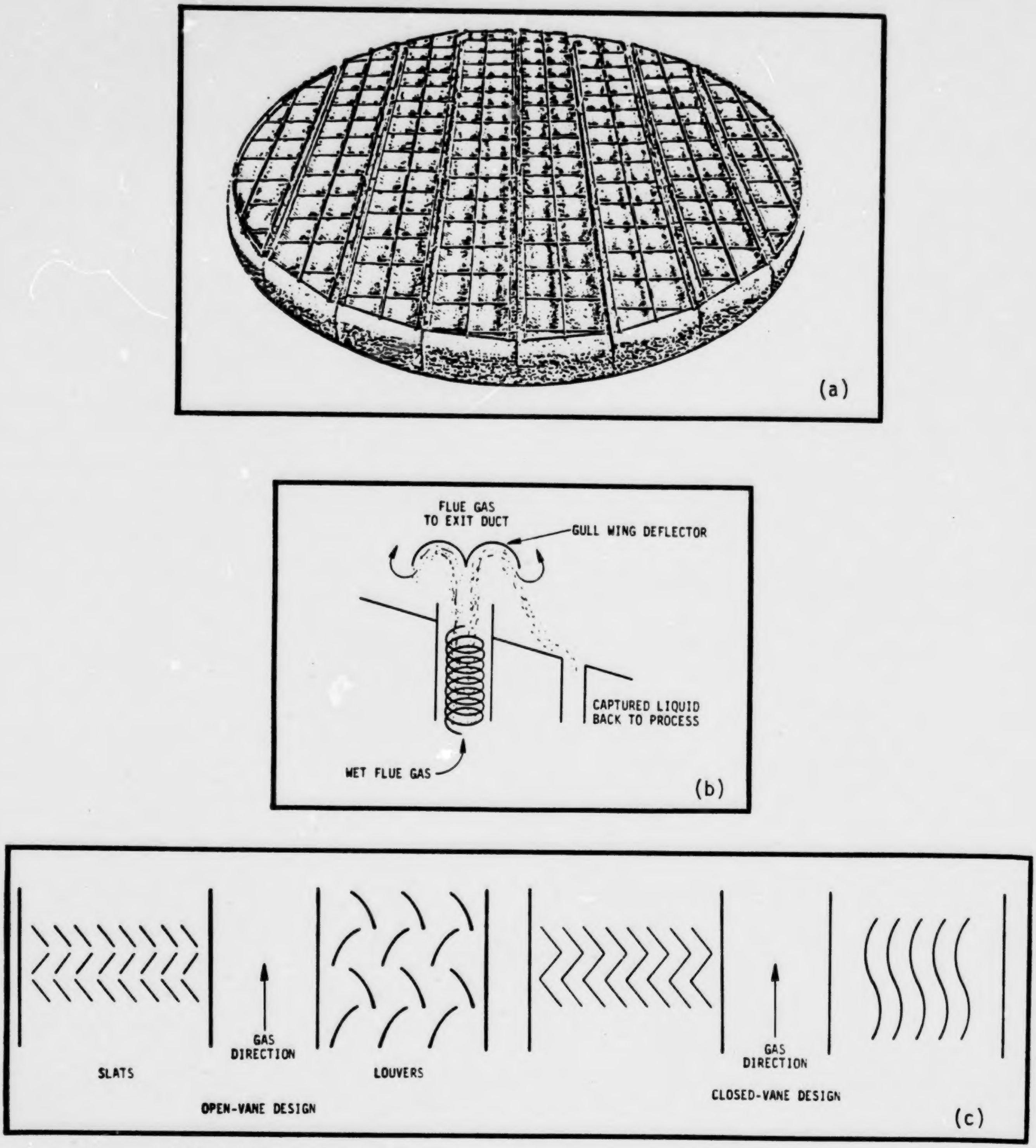
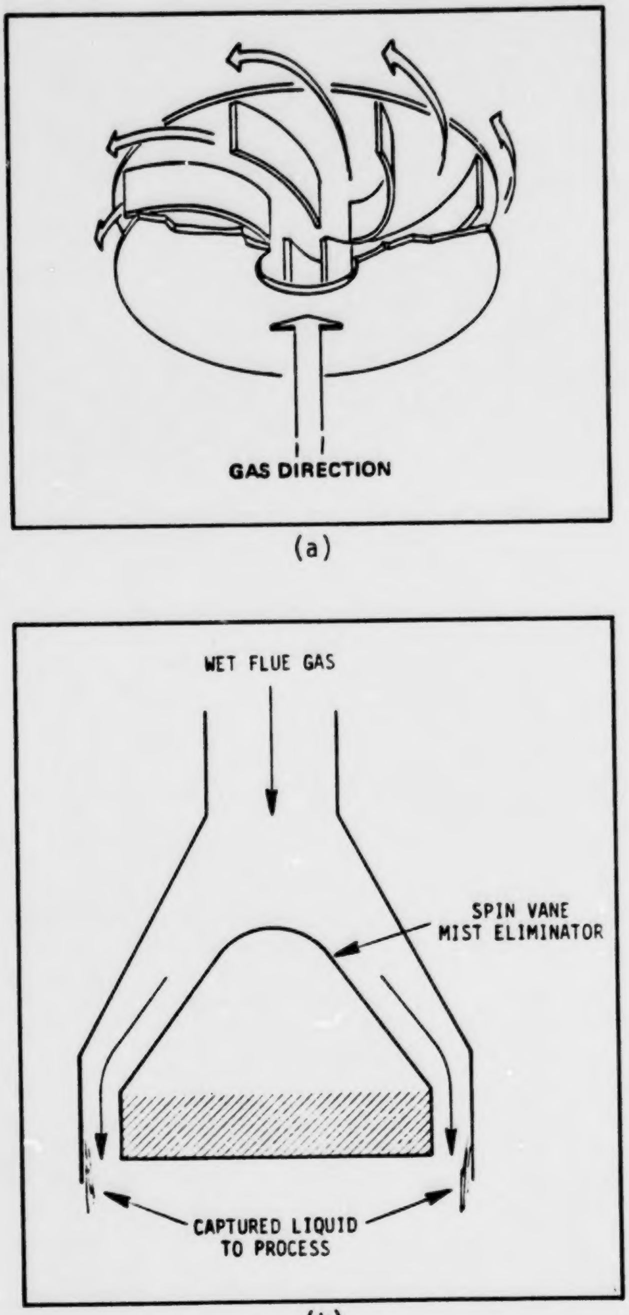

(a)
FLUE GAS
TO EXIT DUCT
GULL WING DEFLECTOR
CAPTURED LIQUID
BACK TO PROCESS
WET FLUE GAS
(b)
SLATS
GAS
DIRECTION
LOUVERS
OPEN-VANE DESIGN
GAS
DIRECTION
CLOSED-VANE DESIGN
(c)

Figure 11. Impingement type mist eliminators: (a) mesh (wire mesh); (b) curved deflector plate (gull-wing); (c) baffle.


GAS DIRECTION
WET FLUE GAS
SPIN VANE MIST ELIMINATOR
CAPTURED LIQUID TO PROCESS

(a)

(b)

Figure 12. Centrifugal type mist eliminators:
(a) radial baffle type radial vane; (b) spin vane type radial vane.

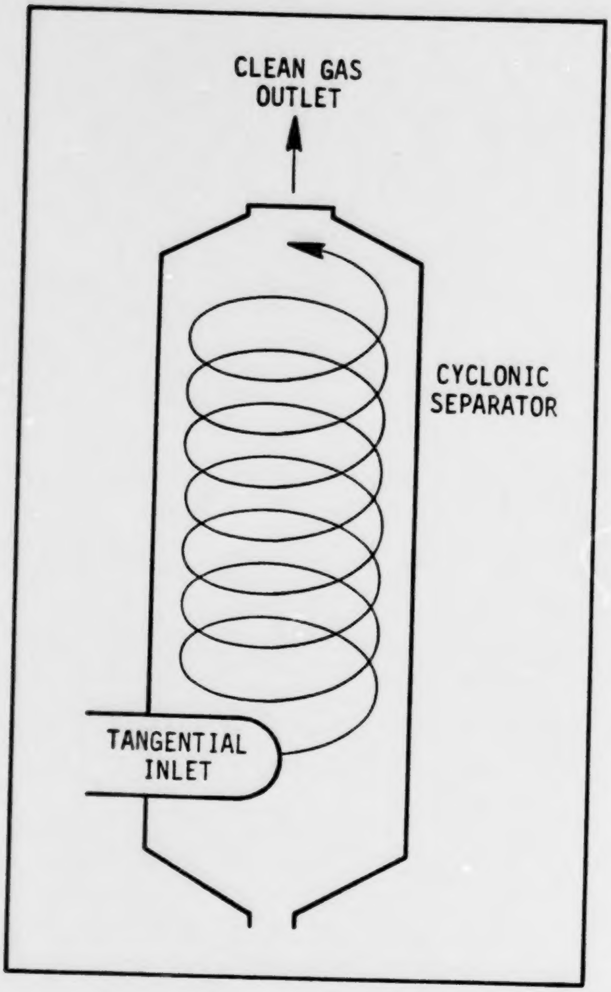

CLEAN GAS OUTLET
CYCLONIC SEPARATOR
TANGENTIAL INLET

Figure 13 . Cyclonic tower.

SECTION 7

BASIC REHEATER TYPES

Reheaters are used to raise the temperature of the scrubbed gas stream in order to prevent condensation and corrosion in the downstream equipment (ducts, fans, and stack) and to avoid a visible plume, and/or enhance plume rise and dispersion. The prevention of condensation and corrosion in the exit ductwork and stack is the primary reason reheaters are included in FGD systems. Wet scrubbing systems, not including reheaters, must be equipped with specially lined stacks ("wet stacks") and often exit ductwork as well to prevent corrosion of the materials. Such liners require special attention and FGD systems using them must be equipped with emergency deluge sprays in the event a temperature excursion should occur. A systematic grouping of the various stack gas reheat methods available for use with FGD systems is provided in Table 7.

7.1 GENERIC AND SPECIFIC CLASSIFICATIONS

The generic classifications shown in Table 7 represent a grouping of reheat methods according to variations in configuration or energy source needed to raise the gas temperature. The specific classifications represent distinct design variations within each generic grouping, and the common classification indicates further design variations within each specific class.

7.1.1 Reheater Classification Descriptions

Of the six generic reheater types listed in Table 7 all but two require external energy addition to achieve the temperature boost downstream of the scrubbing system. Only bypass and waste heat recovery reheaters (and the wet stack alternative) escape this energy cost.

TABLE 7. BASIC REHEATER TYPES

Generic type	Specific types	Common designs
In-line	Steam Hot water	Bare tube Fin tube Shell and tube
Direct combustion	In-line burner External combustion chamber	Natural gas or oil
Indirect hot air	External heat exchanger Boiler preheater	Steam tube bundle Boiler combustion air
Waste heat recovery	Gas-gas Gas-fluid	Wheel type Tube bundle
Exit gas recirculation	Steam heat exchanger	
Bypass	Hot side Cold side	

In-line--

In-line reheat involves the use of a heat exchanger in the flue gas duct (or absorber modules) downstream of the mist eliminator. The heat exchanger is a set of tubes or tube bundles through which the heating medium is circulated. The gas passes over the tubes and picks up thermal energy from the surfaces of the heating tubes. These tubes are typically arranged in banks. Figure 14 is a simplified diagram of an in-line reheater.

In-line reheaters can be classified according to the heating medium: steam or hot water. When steam is used, the inlet steam temperatures and pressures range from 350° to 720°F and 115 to 200 psig, respectively. Saturated steam is preferred because the heat transfer coefficients of condensing steam are much higher than those of superheated steam. The configuration of a reheater using hot water is similar to that of the one using steam. Inlet temperature of the hot water typically ranges from 250° to 350°F and the temperature drop (water) over the heat exchanger is 70° to 80°F.

Fin-tubes are used in some applications because of their superior heat transfer capability. Soot blowers are generally used to periodically remove deposits that build up on the tube surfaces.

Because in-line reheaters are situated in the gas stream, they are prone to corrosion and plugging, the latter due to the reheater's dependence on proper operation of the upstream mist eliminator. Moreover, solids deposited on the tubes can reduce heat transfer considerably, increasing the potential for corrosion of downstream equipment.

Direct Combustion--

The direct combustion reheat system can be classified into two design configurations, one with burners installed in the flue gas duct (in-line burner) and the other with burners installed in an external combustion chamber. As shown in Figure 15, gas or oil is burned and the combustion product gas (at 1200° to 3000°F) is mixed with the flue gas to raise its temperature.

Direct firing requires some care in mixing the hot combustion gas with the cool scrubbed gas. If mixing is not effective, hot spots can develop downstream from the heater, causing damage to the duct lining. Also, maintenance of flame and flame stability are required for effective operation.

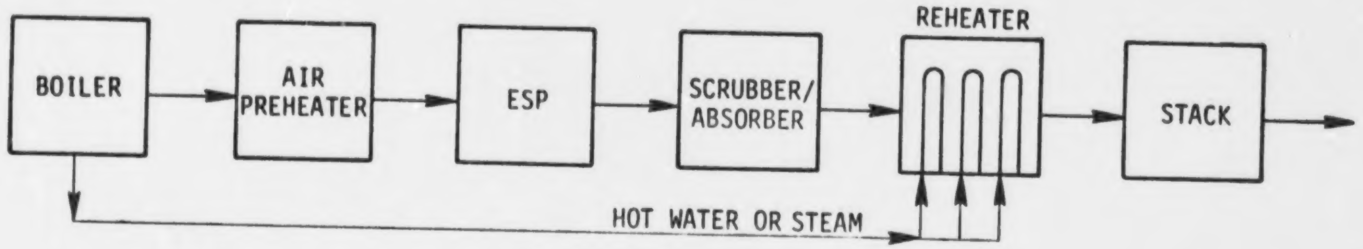

BOILER
AIR PREHEATER
ESP
SCRUBBER/ ABSORBER
REHEATER
STACK
HOT WATER OR STEAM

Figure 14. In-line reheat system.

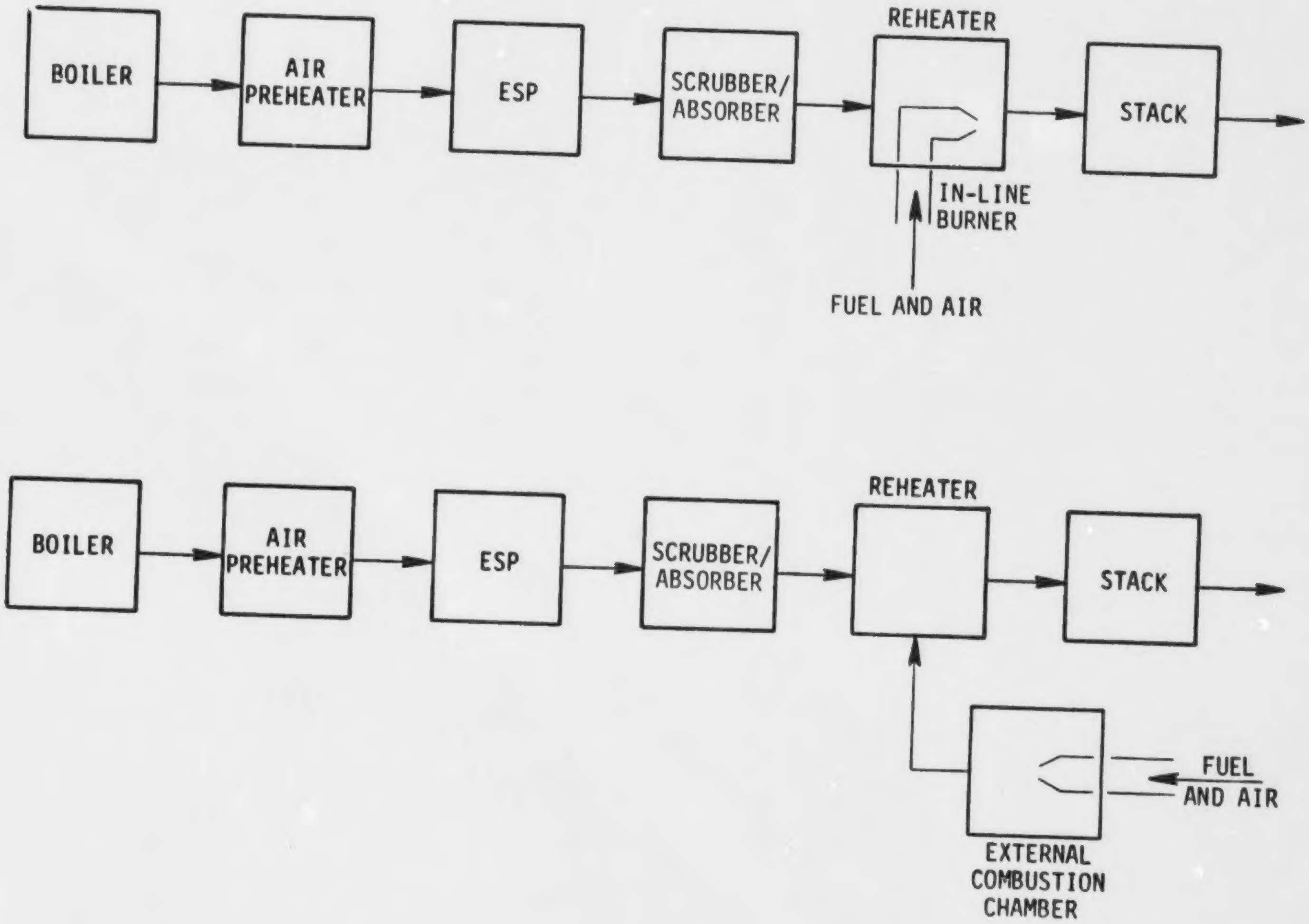

BOILER
AIR PREHEATER
ESP
SCRUBBER/ ABSORBER
REHEATER
STACK
IN-LINE BURNER
FUEL AND AIR
BOILER
AIR PREHEATER
ESP
SCRUBBER/ ABSORBER
REHEATER
STACK
FUEL AND AIR
EXTERNAL COMBUSTION CHAMBER

Figure 15. Direct combustion reheat systems.

The main problems with direct firing are the availability and cost of gas and oil.

Indirect Hot Air--

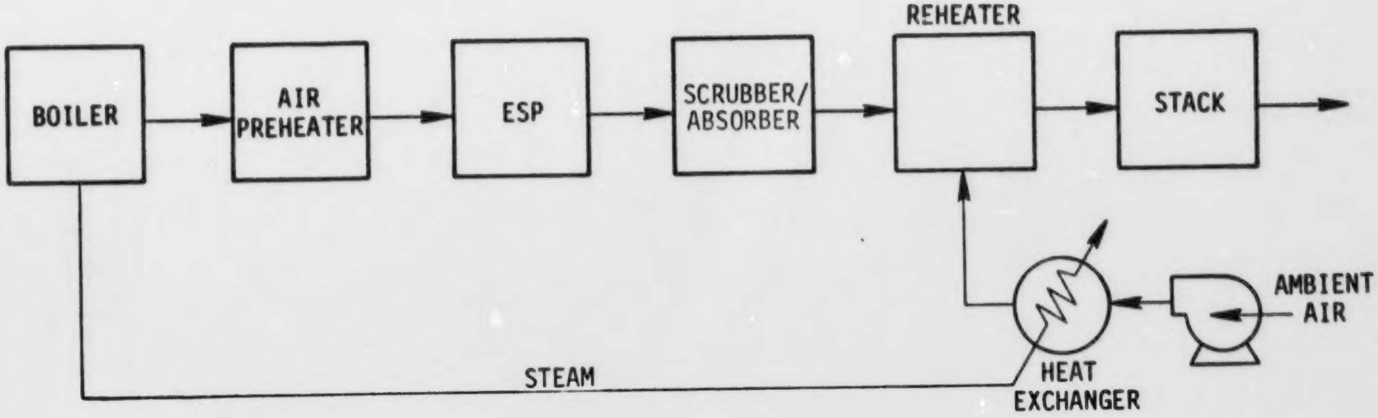
Indirect hot air type reheat systems inject hot ambient air into the wet scrubbed gas stream. There are two types of indirect hot air reheaters: the external heat exchanger and the boiler preheater design (Figure 16a). In the external heat exchanger design reheat is achieved by heating ambient air with an external heat exchanger using steam at temperatures of 350° to 450°F. The heating tubes are usually arranged in two to three banks in the heat exchanger. Hot air and flue gas may be mixed by use of a device such as a set of nozzles or a manifold in the reheater mix chamber section.

A variation of the indirect hot air reheat method involves use of the boiler combustion air preheater to provide hot air for stack gas reheat (Figure 16b). In this case, the temperature of the combustion air entering the boiler would be lower than usual because part of the heat content of the flue gas is used to provide the hot air for stack gas reheat. The preheater would have to be specially designed for this purpose. The preheater would have to accomodate a greater-than-normal amount of air and yield a lower than normal exit temperature.

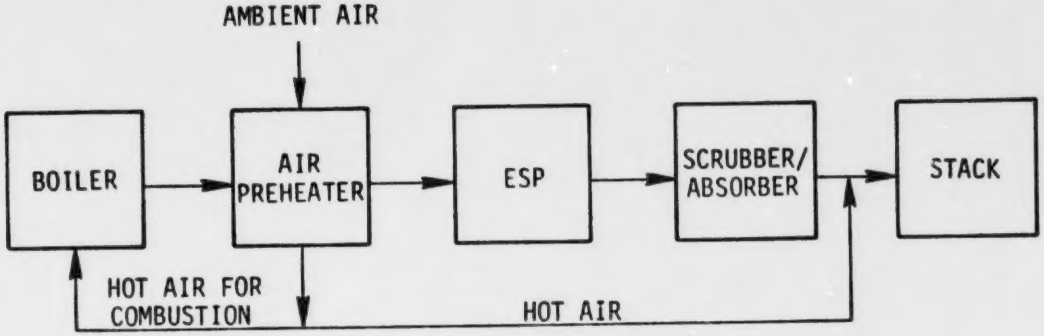
The advantage of indirect hot air reheat over in-line reheat is that no corrosion or plugging occurs because the indirect system is located outside of the scrubber gas discharge duct. The disadvantages include the need for an additional fan to convey hot air; the relatively large amount of space required for the reheat system (compared with other reheat methods); an increase in stack gas volume, which may be undesirable because of the limited capacities of existing ID fans and stacks; and a higher energy consumption, which is needed to heat air from the ambient temperature level and drive the fan. Another advantage is the dilution by the added air addition which reduces the incidence of steam plume formation and gives better plume dispersion.

Waste Heat Recovery--

In the waste heat recovery method (Figure 17), the sensible heat of the hot, dry boiler flue gas, which would otherwise be released in the scrubber, is recovered in an in-line heat exchanger. The heat is used to reheat


BOILER
AIR PREHEATER
ESP
SCRUBBER/ ABSORBER
REHEATER
STACK
AMBIENT AIR
HEAT EXCHANGER
STEAM

a) External heat exchanger.


AMBIENT AIR
BOILER
AIR PREHEATER
ESP
SCRUBBER/ ABSORBER
STACK
HOT AIR FOR COMBUSTION
HOT AIR

b) Boiler preheater.

Figure 16. Indirect hot air reheat system.

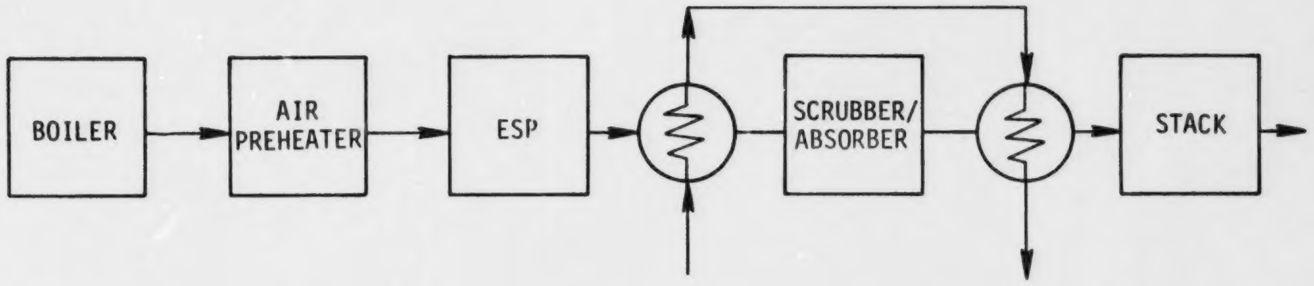

BOILER
AIR PREHEATER
ESP
SCRUBBER/ ABSORBER
STACK

Figure 17. Waste heat recovery reheat system.

the scrubbed stack gas. A direct gas/gas heat exchanger, especially the wheel type (e.g., Ljunstrom), can be used for this purpose. This type of reheat system requires a large heat-transfer area in both the upstream and downstream heat exchangers because of the narrow temperature range involved. Another method involves gas/fluid heat exchange through a medium such as water or a fluid of high heat capacity (e.g., glycol-water mixture), which is circulated through in-line heat exchangers (tubes) located upstream and downstream of the scrubber. With this method, there is a potential for corrosion of the area immediately following the upstream heat exchanger due to acid condensation when the hot SO_2 laden flue gas is cooled prior to the scrubber.

A simplified diagram of recirculation reheat is shown in Figure 18. This type of reheat system can be used in combination with an in-line reheat system.

Bypass Reheat--

In the bypass reheat system, a portion of the hot flue gas from the boiler is allowed to bypass the scrubbing system and is mixed with flue gas that has been processed through the scrubber. Two variations of this method are "hot-side" bypass, in which the flue gas is taken upstream of the boiler air preheater and "cold-side" bypass (Figure 19a), in flue gas is taken downstream of the boiler air preheater (Figure 19b). In the former, a separate particulate removal device (ESP or fabric filter) is required for fly ash control if an upstream particulate collector is not used.

The limiting conditions for application of bypass heat are determined by: (1) the properties of the boiler fuel, such as heating value, sulfur content, and ash content; (2) particulate control ahead of the scrubbing system; (3) the temperature of hot flue gas; (4) the efficiency of the scrubbing system; and (5) emission regulations.

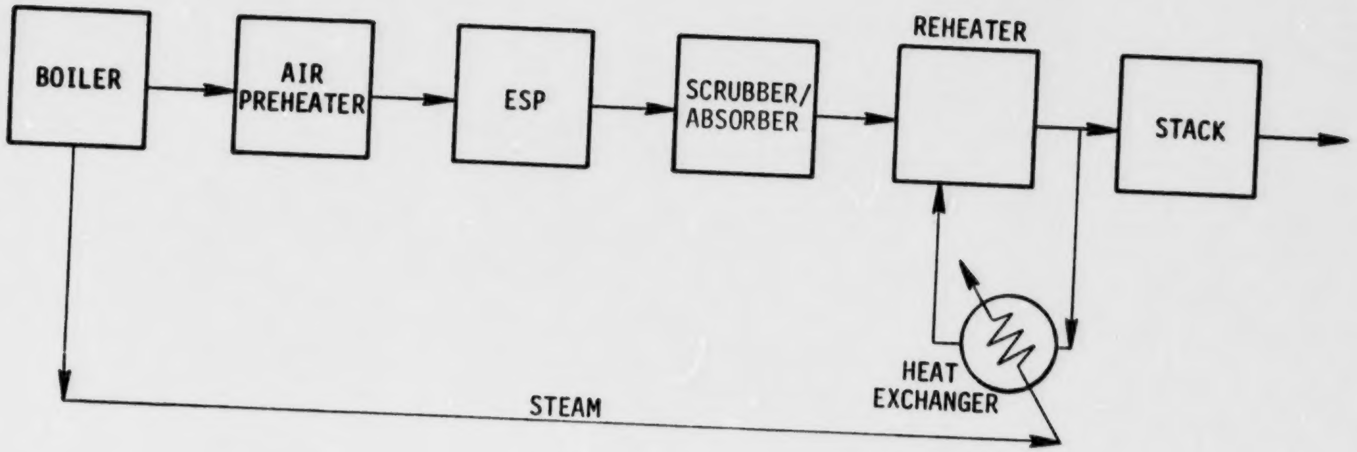
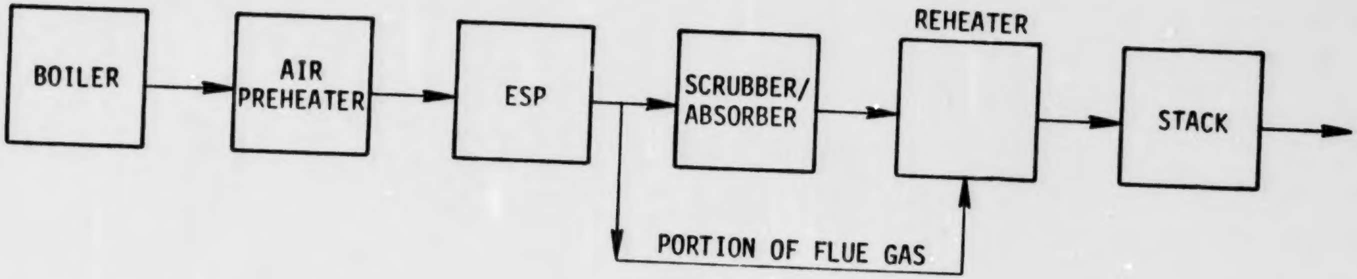
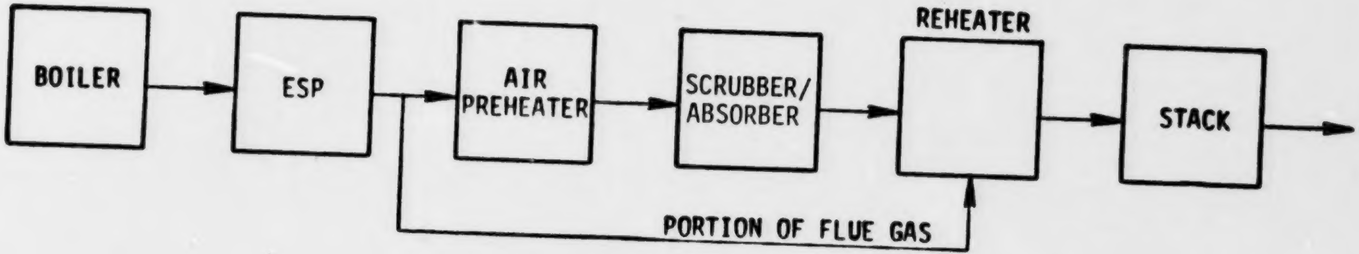

BOILER
AIR PREHEATER
ESP
SCRUBBER/ ABSORBER
REHEATER
STACK
HEAT EXCHANGER
STEAM

Figure 18. Exit gas recirculation reheat system.


BOILER
AIR PREHEATER
ESP
SCRUBBER/ ABSORBER
REHEATER
STACK
PORTION OF FLUE GAS

a.) "Cold side."


BOILER
ESP
AIR PREHEATER
SCRUBBER/ ABSORBER
REHEATER
STACK
PORTION OF FLUE GAS

b.) "Hot side."

Figure 19. Flue gas bypass reheat systems.

SECTION 8

BASIC SOLIDS DEWATERING DEVICE TYPES

Dewatering devices are used to decrease the moisture level of an FGD waste slurry to a degree that the material can be handled more easily and disposed as a stable earth-like solid suitable for landfill. The function of a solids dewatering device is to concentrate solids and recover water.

8.1 GENERIC AND SPECIFIC CLASSIFICATIONS

Table 8 contains the generic and specific classifications developed to identify the solids dewatering device types contained in FGDIS. This table also provides common design classifications which further distinguish one specific type from another.

8.1.1 Solids Dewatering Classification Descriptions

Thickener--

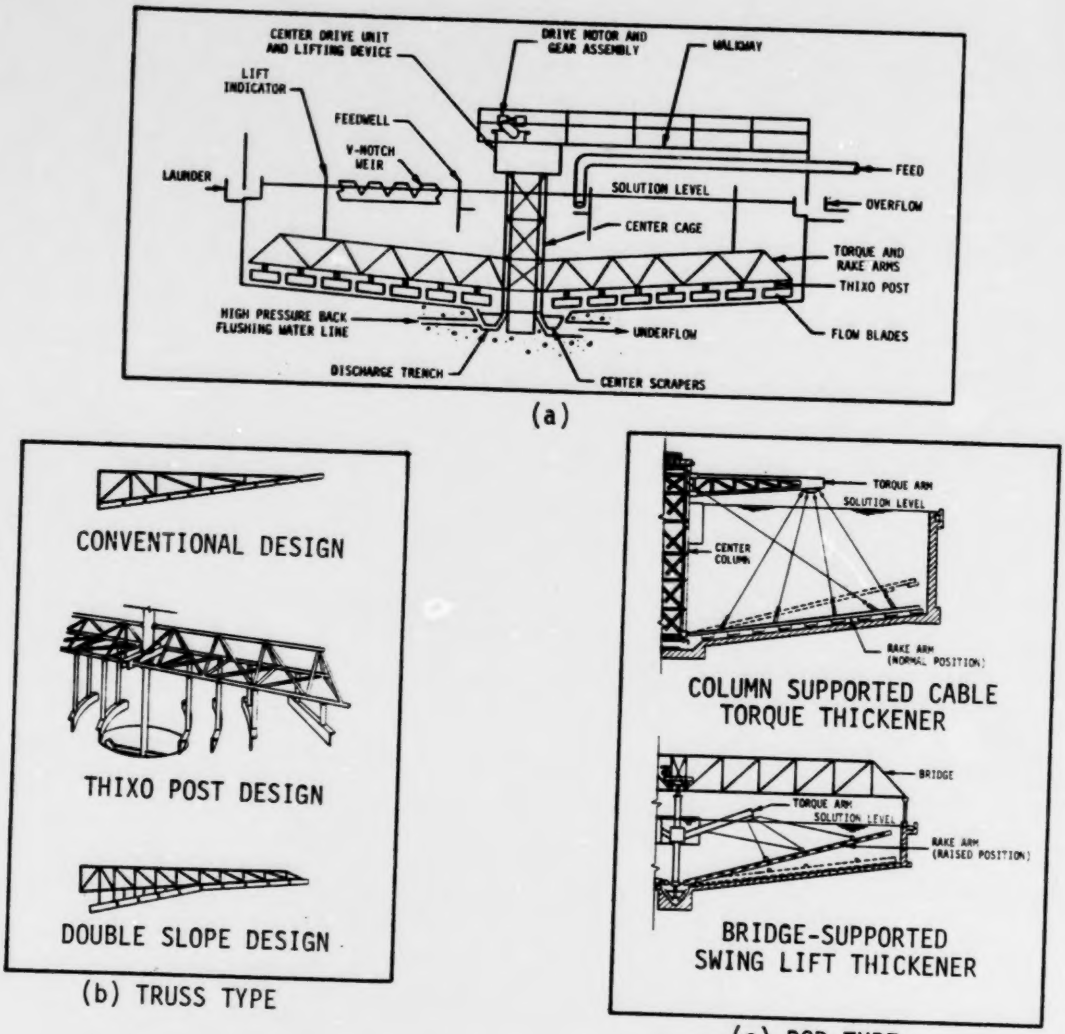
A thickener is a sedimentation device that concentrates a slurry by gravity so that the settled solids may be disposed of and the clarified liquid recycled. The two basic thickener types are categorized as gravity or plate.

The scrubber slurry usually enters a thickener at a solids level of about 5 to 15 percent and the underflow is discharged at a concentration of 30 to 40 percent solids.

A typical gravity thickener (Figure 20) consists of a large circular holding tank with a central vertical shaft that is supported either by internal structural design, by a center column, or by a bridge. Two long, radial rake arms extend from the lower end of the vertical shaft; two short arms may be added when necessary to rake the inner area. Plow blades are mounted on the arms at an oblique angle (with the trailing edge toward the center shaft), with a clearance of 1.5 to 3 in. from the bottom of the tank. They can be arranged identically on each arm or in an offset pattern so that

TABLE 8. BASIC SOLIDS DEWATERING DEVICE TYPES

Generic	Specific	Common designs
Thickener	Gravity	Truss type Rod type Picket type
	Plate	Inclined plate Inclined tube
Vacuum filter	Drum	Rotary drum Belt filter
	Horizontal belt	
Centrifuge	Horizontal solid bowl	Cylindrical/conical
Hydrocyclone		

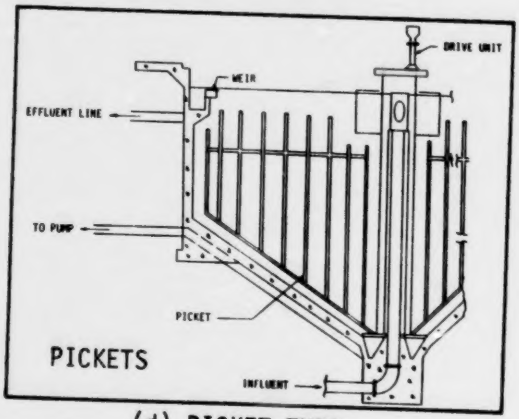


(a)

(b) TRUSS TYPE

(c) ROD TYPE

CENTER DRIVE UNIT AND LIFTING DEVICE
DRIVE MOTOR AND GEAR ASSEMBLY
WALKWAY
LIFT INDICATOR
FEEDWELL
V-NOTCH WEIR
LAUNDER
FEED
SOLUTION LEVEL
OVERFLOW
CENTER CAGE
TORQUE AND RAKE ARMS
THIXO POST
HIGH PRESSURE BACK FLUSHING WATER LINE
UNDERFLOW
FLOW BLADES
DISCHARGE TRENCH
CENTER SCRAPERS
CONVENTIONAL DESIGN
THIXO POST DESIGN
DOUBLE SLOPE DESIGN
TORQUE ARM
SOLUTION LEVEL
CENTER COLUMN
RAKE ARM (NORMAL POSITION)
COLUMN SUPPORTED CABLE TORQUE THICKENER
BRIDGE
TORQUE ARM
SOLUTION LEVEL
RAKE ARM (RAISED POSITION)
BRIDGE-SUPPORTED SWING LIFT THICKENER



(d) PICKET TYPE

DRIVE UNIT
WEIR
EFFLUENT LINE
TO PUMP
PICKET
PICKETS
INFLUENT

Figure 20. Gravity type thickener: (a) cross-section of a conventional gravity thickener; (b) design options for truss type gravity thickeners; (c) design options for rod type gravity thickeners; (d) typical gravity thickener cross-section of the picket type.

the bottom is swept either once or twice during each revolution. The bottom of the tank is usually graded at a slope of 1:12 to 1.75:12 (4.8 to 8.3°) from the center. The settled sludge forms a blanket on the bottom of the thickener tank and is pushed gently toward the central discharge outlet. Center scrapers clear the discharge trench and move the solid deposits toward the underflow discharge point.

Gravity type thickeners may be characterized by either a truss or rod type rake arm or by a picket type rake assembly. The main function of rake arms and pickets is to move the settled solids to the central discharge point. Rake arms must be strong enough for the required torque, although their design also depends on the nature of the solids.

The conventional design for the truss-type arm is shown in Figure 20b. This type rake also acts as a torque arm. Its blades are bolted to the bottom chord of the truss structure. When sludges reach high density and high viscosity, the blades and the rake arm structure tend to form the sludge into an immobile "donut" or "island." Proper blade angles and extension of the blades below the raking arms by means of vertical posts, Thixo posts in Figure 20b, help eliminate this phenomenom by leaving fewer structural members to move through the sludge in the critical center area. In larger thickeners (300 to 400 ft diameter), the center depth would be excessive if a single slope were employed. The double sloping design, Figure 20b, eliminates this problem.

Rod-type rake arms are either of the column-supported or bridge-supported designs (Figure 20c). Column-supported and bridge-supported designs generally employ two long arms with the option of two short ones, the latter added when necessary to rake the inner area.

The rod-type rake arm has a hinged design, as shown in Figure 20c. The arm is simply a long pipe pivoted at the center column either by a single tilted pin or by two pins, one horizontal and one vertical. The rake arms are suspended and dragged by cables from torque arms, which rotate 30° to 45° ahead of them. The interesting feature of this design is that the pivot pins allow the rake arms to swing over heavy deposits of coarse material. This design has further advantages over the truss-type in that it also offers lighter dead load, less drag, and less tendency for scale buildup in the rake arms.

The diameter of a lift-arm thickener is usually limited to 150 ft, since even a small lifting action near the center creates excessive swing at the tip of the rake arms. The lack of positive control of the lifting and lowering action is another problem with this design.

In conventional thickeners, deep trusses or vertical pickets may be provided in the sludge collection mechanisms of the thickener. A typical gravity thickener with pickets is shown in Figure 20d.

The role of pickets is believed to be in opening up the channels for water to escape, thus promoting solid densification. However, the mechanism by which the pickets work and their proper design is not well understood.

When space is limited, a high-capacity thickener may be used. Such a unit is the plate-type thickener that has been used successfully in the phosphate industry. The plate-type thickener consists of two tanks: an upper rectangular unit contains a series of parallel, slotted plates (or tubes) inclined at a 55-degree angle and serves as a high-rate gravity settler; a lower circular tank functions as a thickener with a picket-fence- type sludge rake and houses the underflow outlet. The arrangement of plates in the rectangular tank increases the settling capacity of the thickener and substantially reduces space requirements.

In plate-type thickeners inclined plates or tubes are used to increase the settling surface area. The settling volume is divided into many shallow chambers. A Lamella plate-type thickener is shown in Figure 21. In this design wastewater flows up through the spaces in between parallel inclined plates. The plates provide surface area for gravity settling. The flow is directed against the bottom of the plates and the coalescing solids slide down into the sludge thickening chamber. A rake in the collection chamber collects the sludge which is pumped off as required.

Vacuum Filter--

Vacuum filters are economical for continuous service and are widely used because they can be operated successfully at relatively high turndown ratios over a broad range of feed solids concentrations. A vacuum filter also provides more operating flexibility than other types of dewatering devices, and produces a drier product. Because a vacuum filter will not yield an

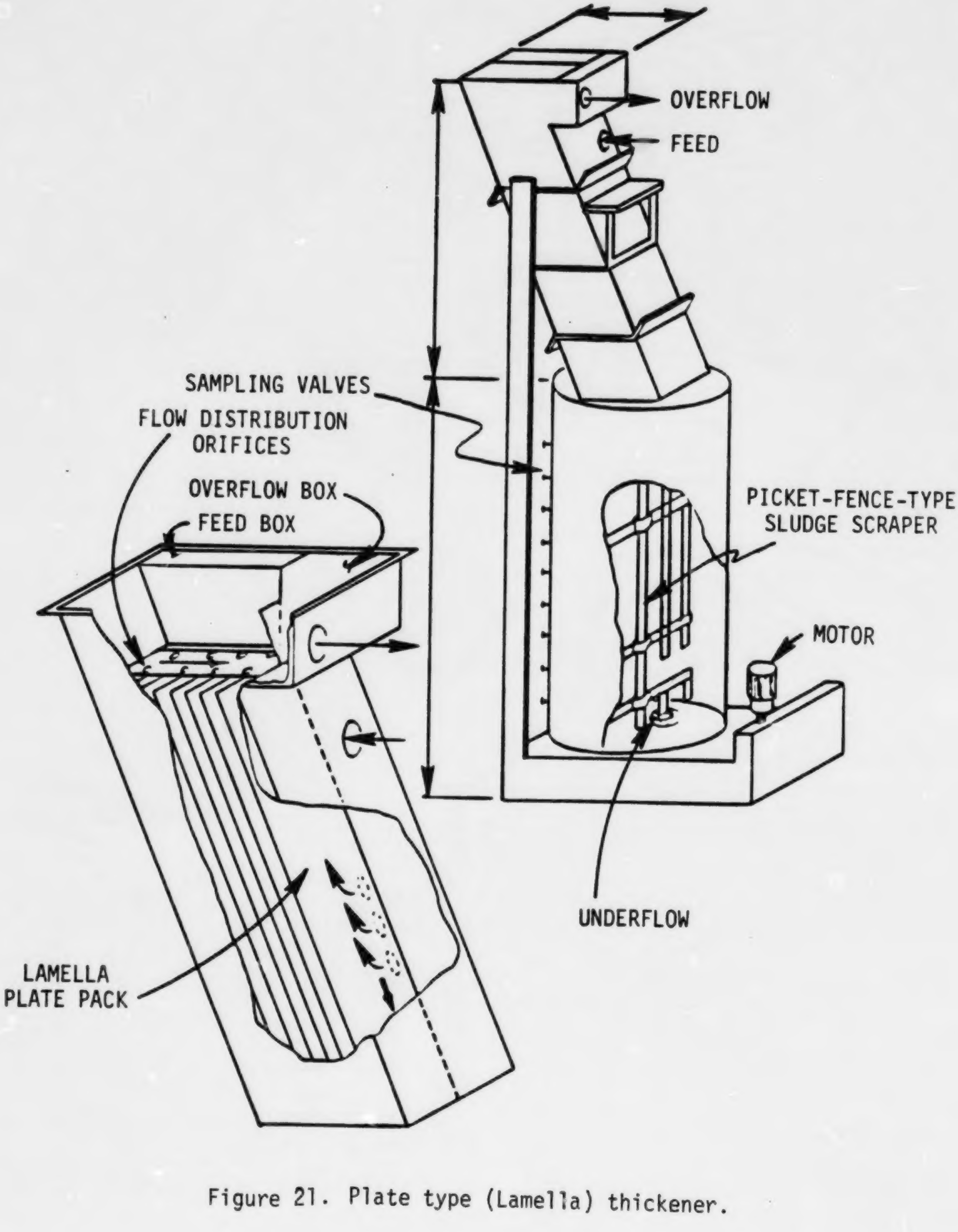

OVERFLOW
FEED
SAMPLING VALVES
FLOW DISTRIBUTION ORIFICES
OVERFLOW BOX
FEED BOX
PICKET-FENCE-TYPE SLUDGE SCRAPER
MOTOR
UNDERFLOW
LAMELLA PLATE PACK

Figure 21. Plate type (Lamella) thickener.

acceptable filter cake if the feed solids content is too low, it is usually preceded by a thickener or hydrocyclone.

A vacuum filter produces filter cake of 45 to 75 percent solids from feed slurries containing 20 to 35 percent solids. The filtrate containing 0.6 to 1.5 percent solids is recycled to the thickener.

Normally, the filters are installed at an elevated location so that the cake solids discharging from the filter can drop into a chute leading to a storage hopper for easy loading into a truck. If an elevated position is undesirable, a belt conveyor may be used to collect the solids discharged from the filter and carry them to a raised storage hopper, again to permit easy loading.

Two types of vacuum filters are used in conventional FGD system designs: drum and horizontal belt. Each has different characteristics and applicability. The drum type, which is the most widely applied, is of primary interest here.

There are two types of drum type vacuum filters: the rotary-drum and belt filter. A rotary-drum vacuum filter is depicted in Figure 22a. The drum is divided into sections, each connected through ports in the trunnion to the discharge head. The slurry is fed to a tank in which the solids are held uniformly in suspension by an agitator. As the drum rotates, the faces of the sections pass successively through the slurry. The vacuum in the sections draw filtrate through the filter medium, depositing the suspended solids on the filter drum as cake. As the cake leaves the slurry rising up on the rotating belt, it is completely saturated with filtrate. The cake undergoes dewatering by the simultaneous flow of air and filtrate in the cake drying zone. Drying is negligible when the air is at room temperature. Finally, the cake is removed in the discharge zone either by a scraper or a string-type discharge stretched across the rolling filter belt, which may be assisted by a slight air reversal through the filter cloth.

The belt filter (Figure 22b) is an improved version of the rotary-drum filter. The filter medium is lifted from the drum after the dewatering portion of the cycle is completed and is passed over a small diameter roller to effect cake removal. This rapid change in direction ensures a complete discharge of cake without the need of a scraper. Thus, the filter cloth life is comparatively long. After cake discharge, the medium is subjected to washing on both sides. This arrangement provides a clean medium for each

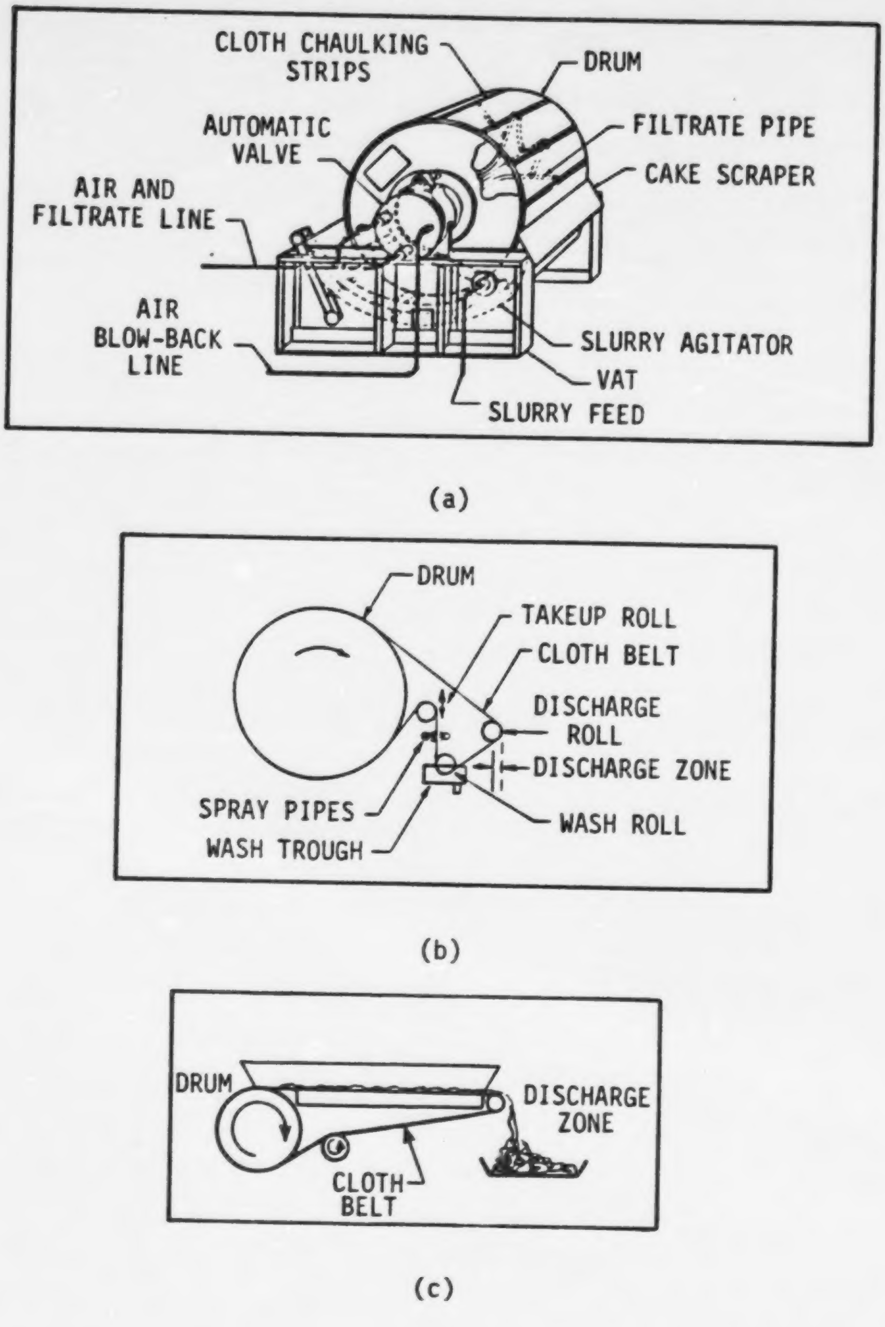

CLOTH CHAULKING STRIPS
DRUM
AUTOMATIC VALVE
FILTRATE PIPE
CAKE SCRAPER
AIR AND FILTRATE LINE
AIR BLOW-BACK LINE
SLURRY AGITATOR
VAT
SLURRY FEED
(a)
DRUM
TAKEUP ROLL
CLOTH BELT
DISCHARGE ROLL
DISCHARGE ZONE
SPRAY PIPES
WASH TROUGH
WASH ROLL
(b)
DRUM
DISCHARGE ZONE
CLOTH BELT
(c)

Figure 22. Vacuum filter types included in FGDIS: (a) rotary drum; (b) belt filter-type drum; (c) horizontal belt.

filter cycle and prevents blinding, a particular advantage in filtering of solids which tend to blind the medium. The lifting of the filter medium from the drum usually results in the reduction of sludge drying time. In some cases, even a 50 percent reduction of drying time may result from a belt type arrangement.

The horizontal belt (Figure 22c) filters are designed for dewatering quick-draining, coarse solids that cannot be retained on a rotating filter belt as it rises vertically. The horizontal belt type vacuum filter is not usually used in FGD systems.

Centrifuge--

Centrifuges are widely used for solids dewatering in FGD systems because they are generally reliable and efficient. The product of a modern centrifuge is consistent and uniform and can be easily handled. Centrifuges effectively create high centrifugal forces, about 4000 times gravity. The equipment is relatively small and can separate bulk solids rapidly with a short residence time.

There are two types of centrifugal separators: those that settle and those that filter. A settling centrifuge uses centrifugal force to increase the settling rate over that obtainable by gravity settling which is done by increasing the apparent difference between densities of the phases. A filtering centrifuge generates by centrifugal action the pressure needed to force the liquid through a filter cloth.

Figure 23 shows a continuous settling, horizontal solid-bowl dewatering centrifuge. The principal elements are the rotating bowl, which is the settling vessel, and the conveyor, which discharges the settled solids. The cylindrical/conical solid bowl design is the only centrifuge design used commercially for FGD system waste. Adjustable overflow weirs at the larger end of the bowl discharge the clarified effluent, and ports on the opposite end discharge the dewatered sludge cakes. As the bowl rotates, centrifugal force causes the slurry to form an annular pool, the depth of which is determined by adjustment of the effluent weirs. A portion of the bowl is of reduced diameter to prevent its being submerged in the pool; thus it forms a drainage deck for the solids as they are conveyed across it. Feed enters through a stationary supply pipe and passes through the conveyor hub into the

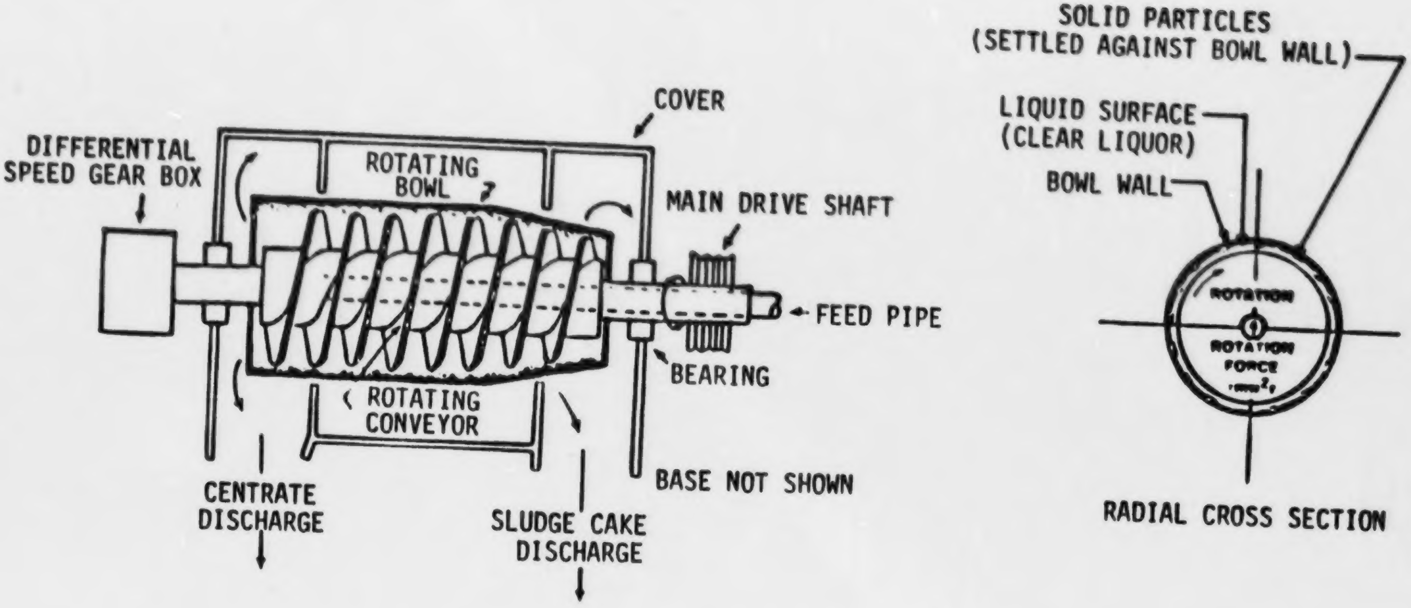

DIFFERENTIAL SPEED GEAR BOX
COVER
ROTATING BOWL
MAIN DRIVE SHAFT
FEED PIPE
BEARING
ROTATING CONVEYOR
BASE NOT SHOWN
CENTRATE DISCHARGE
SLUDGE CAKE DISCHARGE
SOLID PARTICLES (SETTLED AGAINST BOWL WALL)
LIQUID SURFACE (CLEAR LIQUOR)
BOWL WALL
ROTATION
ROTATION FORCE
RADIAL CROSS SECTION

Figure 23. Cross-section of solid-bowl centrifuge.

bowl. As the solids settle to the outer edges of the bowl, they are picked up by the conveyor scroll and continuously overflow the effluent weirs. In a recent study with feed of 16 to 20 weight percent solids, the resultant solids concentrations ranged from 0.7 to 4 weight percent in the effluent and from 60 to 70 percent in the cake. The concentrations were dependent on feed rate and bowl rotation speed (3300 to 5400 rpm).

Hydrocyclone--

A hydrocyclone type solids separator is a small, simply constructed device used extensively for the classification and dewatering of slurries. It can rapidly separate bulk solids from process streams. Although it is an excellent low-cost dewatering device, it is not very effective in producing clarified overflow. The product of a hydrocyclone solids separator, therefore, is often fed to another unit, such as a centrifuge or filter, for additional dewatering. The hydrocyclone also requires frequent maintenance because of high rates of wear, erosion, and corrosion by fly ash and slurries from the SO_2 scrubbing system.

A typical hydrocyclone (Figure 24) consists of a vertical cylinder with a conical bottom, a tangential inlet near the top, and an outlet for solids at the bottom of the cone. The fluid overflow pipe is usually extended into the cylinder to prevent short-circuiting of fluid from inlet to overflow.

The inlet piping imparts a rotating motion to the incoming fluid. The path of the fluid follows a downward vortex, or spiral, adjacent to the wall and reaching to the bottom of the cone. The fluid stream moves upward in a tighter spiral, concentric with the first, and leaves, still whirling, through the outlet pipe. Both spirals rotate in the same direction. The particles settle to the side walls and slide down the inclined wall to the apex of the cone. They are then discharged through an underflow orifice.

A hydrocyclone solids separator is a settling device in which a strong centrifugal force is used for separation. The centrifugal force of such a device ranges from 5 times gravity in large, low-velocity units to 2500 times gravity in small, high-pressure units.

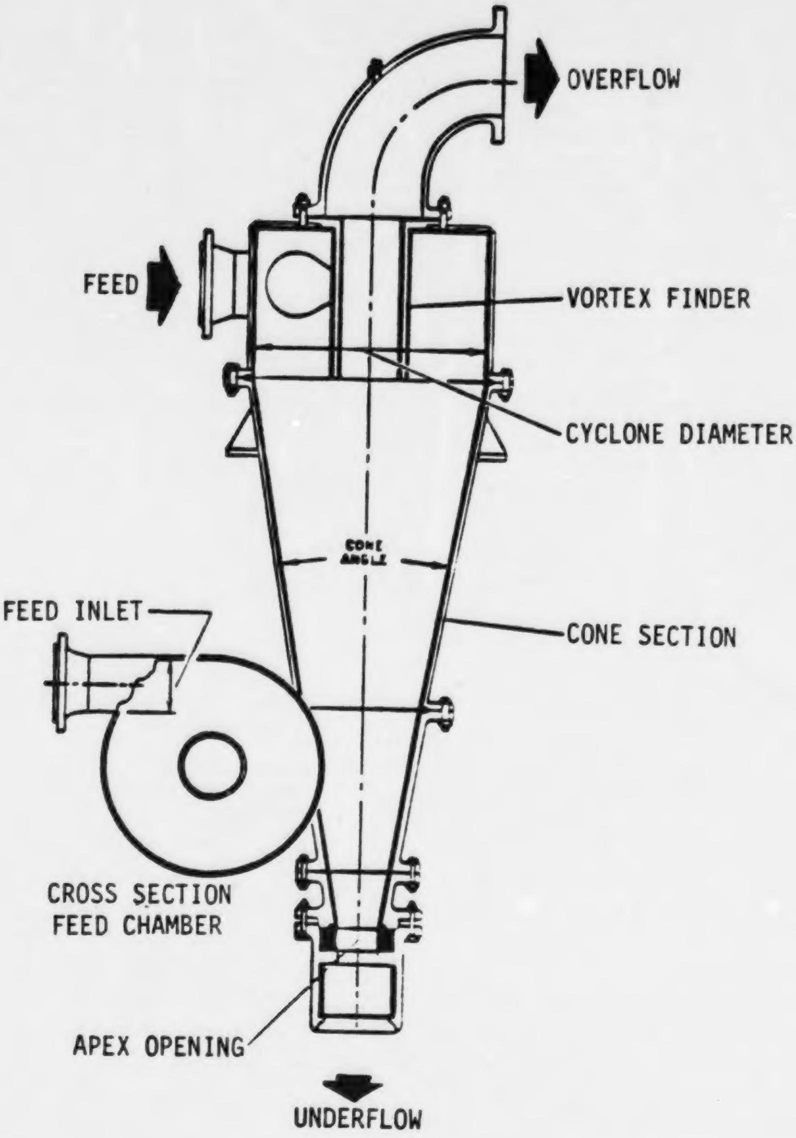

OVERFLOW
FEED
VORTEX FINDER
CYCLONE DIAMETER
CONE ANGLE
FEED INLET
CONE SECTION
CROSS SECTION
FEED CHAMBER
APEX OPENING
UNDERFLOW

Figure 24. Hydrocyclone solids separator.

SECTION 9

BASIC SLUDGE PROCESSING TYPES

Sludge may be processed as a treated or untreated material prior to final disposal in a pond or landfill. Processing types may range from a direct bleed from the scrubbing system to sludge fixation which yields a chemically stable, solid product. The term "processing type" refers to the first phase in handling of the waste product from an FGD system. Dewatering devices and disposal methods, etc., are addressed elsewhere.

9.1 GENERIC AND SPECIFIC CLASSIFICATIONS

Table 9 contains the generic and specific classifications developed to identify the sludge processing types contained in FGDIS. This table also provides common designs for the specific sludge processing types.

9.1.1 Sludge Processing Classification Descriptions

Treated--

Sludge from FGD systems may be treated by forced oxidation, fixation, or stabilization. These terms are defined as follows:

Forced oxidation--Forced oxidation consists of the completion of the sulfite to sulfate reaction of a calcium based (lime or limestone) sludge by sparging or otherwise forcing air through the material. The advantages of oxidation of calcium sulfite to calcium sulfate (gypsum) include better settling and filtering properties, less disposal space required, good structural properties of the disposed waste, potential for utilization of the gypsum, and minimal chemical oxygen demand of the disposed material. Sludge may be forcibly oxidized in a recycle bleed stream where the aqueous calcium sulfite is oxidized to the less soluble calcium sulfate state. The calcium sulfate precipitates leaving a clear liquor stream for recycle (Figure 25). Another alternative is to perform the oxidation of the aqueous calcium sulfite in a bleed stream that is not recycled.

TABLE 9. BASIC SLUDGE PROCESSING TYPES

Generic	Specific	Common designs
Treated	Forced oxidation	Recycle stream Bleed stream
	Fixation	Fly ash Fly ash/lime Blast furnace slag Lime
	Stabilization	Fly ash Bottom ash Earth
Untreated	Bleed Thickened Dewatered	

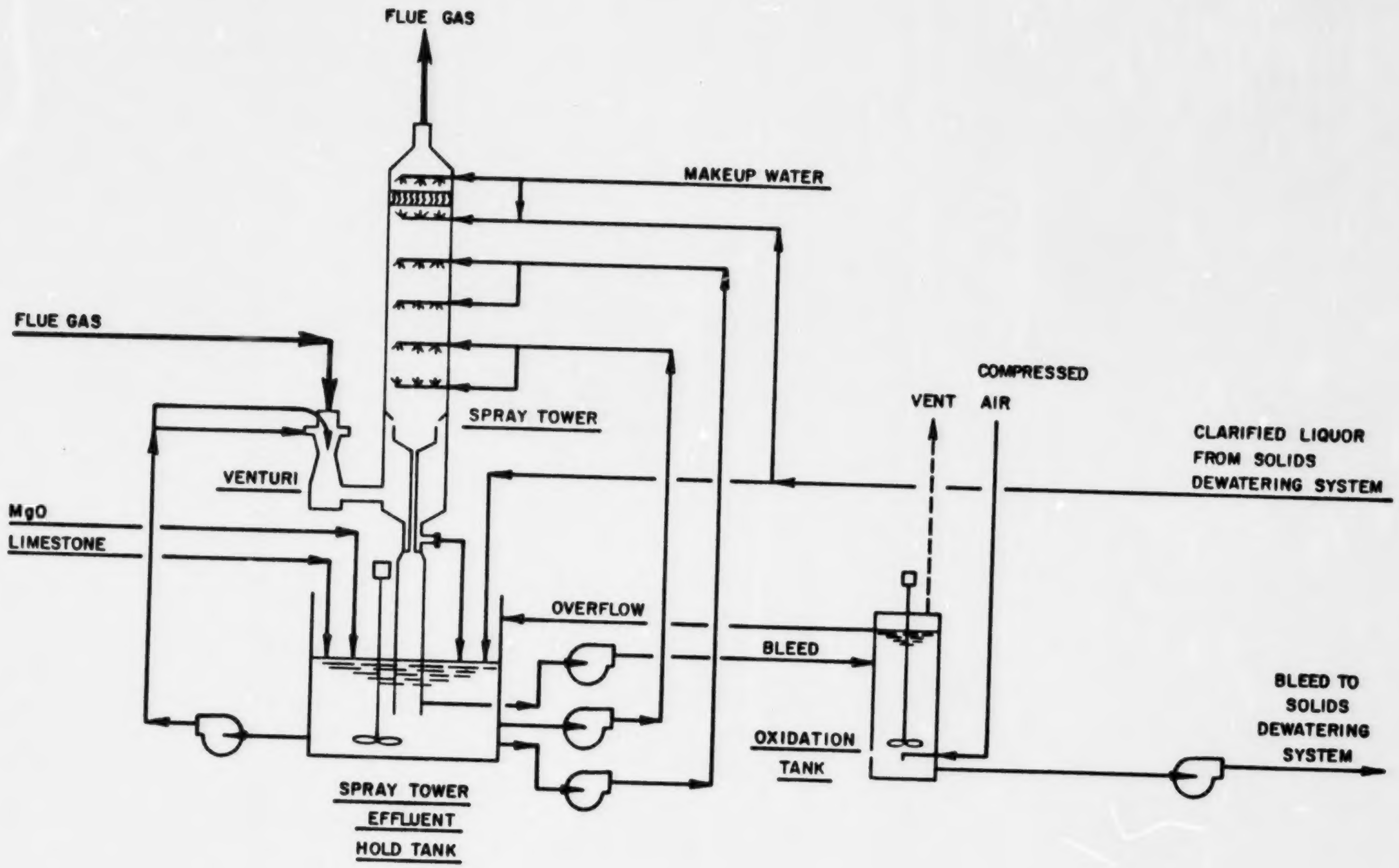

FLUE GAS
MAKEUP WATER
FLUE GAS
COMPRESSED
VENT
AIR
SPRAY TOWER
CLARIFIED LIQUOR
FROM SOLIDS
DEWATERING SYSTEM
VENTURI
MgO
LIMESTONE
OVERFLOW
BLEED
BLEED TO
SOLIDS
DEWATERING
SYSTEM
OXIDATION
TANK
SPRAY TOWER
EFFLUENT
HOLD TANK

Figure 25. Forced oxidation system on a bleed stream from an FGD system.

Fixation--Fixation is effected by dewatering and increasing the chemical stability of FGD waste through chemical means. This may be accomplished by the addition of alkali, alkaline fly ash, etc., in addition to dewatering and the addition of inert solids or the use of commercial processes such as Poz-O-Tec (primarily lime addition) or Calcilox (primarily blast furnace slag addition) to produce a chemically stable solid.

Fixation processes are identical to stabilization processes except that fixation processes take advantage of chemical interactions between different components or additives in the sludge. Figures 26a, 26b, and 26c show fixation alternatives. As shown in this figure the fixated sludge may be ponded directly, ponded then landfilled or further dewatered and directly landfilled.

Fixation reactions are similar to that of portland cement formation. The setting or hardening of portland cement is a hydration reaction. When portland cement is mixed with water, the water chemically combines with the cement during the reaction process to become part of the final solid product. The solid products form a matrix which physically encapsulates and sometimes chemically bonds any filler which may be present. Although portland cement is quite effective as a stabilizing agent, it is not a cost effective method for FGD waste fixation because of the relatively high cost of the material. Blast furnace slag and flyash, being waste products themselves, contribute to lowering costs below those for any system utilizing portland cement as the cementitious stabilizing agent. Blast furnace slag hydrates more slowly than portland cement, but its final strength is nearly the same. Blast furnace slag reaction products are practically identical to those of portland cement (Figure 26c). The constituents of alkaline flyash are also basically the same as those of portland cement. The lime/flyash reaction is very similar to the blast furnace slag reaction, only slower, and it does not yield as high a strength if the materials are of the same density. The composition of flyash is quite variable.

Stabilization--Stabilization is accomplished by reducing the moisture content of the sludge to the point that structural properties are optimized when the material is disposed of in a landfill. This may be accomplished by the addition of non-alkaline flyash and/or using a vacuum filter or centrifuge. The purpose of stabilization is to enable the placement of the maximum

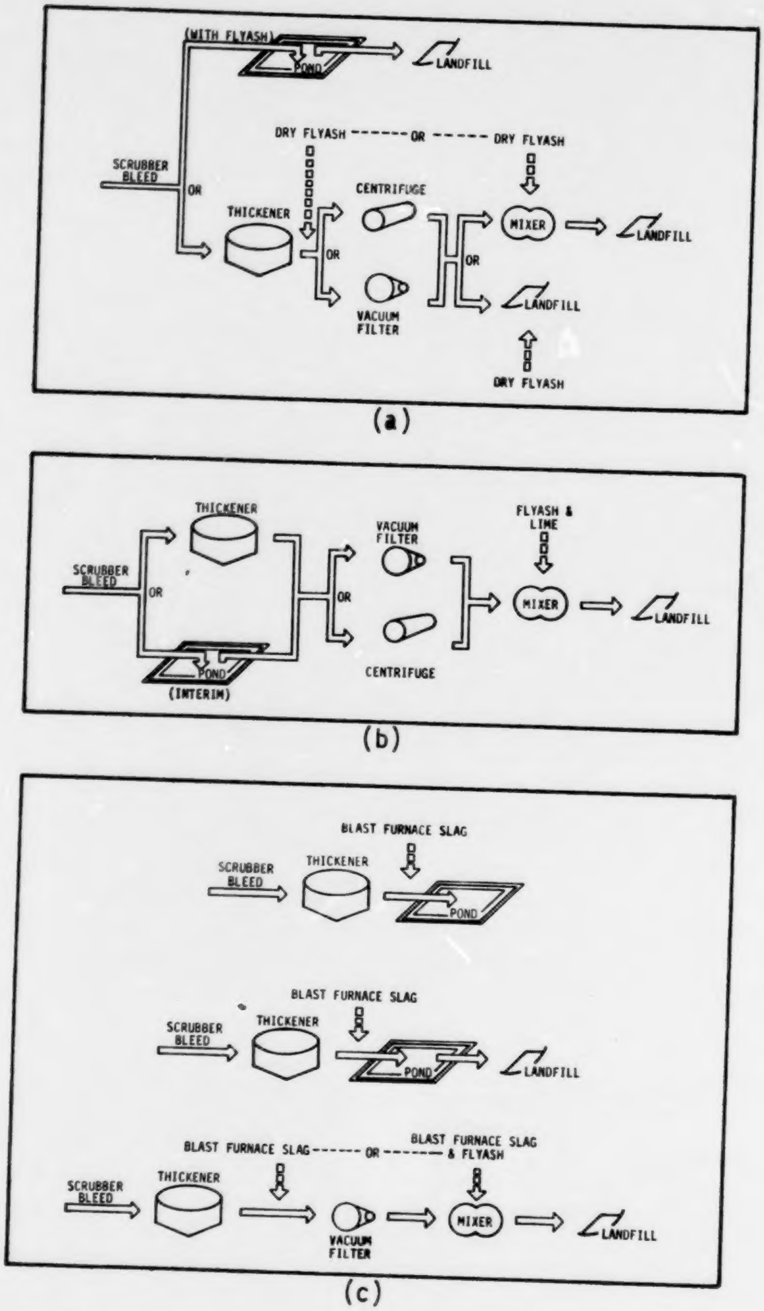

(WITH FLYASH)
POND
LANDFILL
DRY FLYASH ------ OR ------ DRY FLYASH
SCRUBBER BLEED
OR
CENTRIFUGE
THICKENER
MIXER
LANDFILL
OR
OR
VACUUM FILTER
LANDFILL
DRY FLYASH
(a)
THICKENER
VACUUM FILTER
FLYASH & LIME
SCRUBBER BLEED
OR
OR
MIXER
LANDFILL
POND
(INTERIM)
CENTRIFUGE
(b)
BLAST FURNACE SLAG
SCRUBBER BLEED
THICKENER
POND
BLAST FURNACE SLAG
SCRUBBER BLEED
THICKENER
POND
LANDFILL
BLAST FURNACE SLAG ------ OR ------ BLAST FURNACE SLAG & FLYASH
SCRUBBER BLEED
THICKENER
VACUUM FILTER
MIXER
LANDFILL
(c)

Figure 26. Fixation alternatives: (a) alkaline flyash; (b) alkaline flyash/lime; (c) blast furnace slag.

quantity of material in a given disposal area to improve shear strength of the sludge and to reduce permeability. No cementious type reaction is intended. Figure 27 shows an example of nonalkaline flyash blending alternatives to effect stabilization. Bottom ash or earth blending would be performed similarly.

Dewatering methods, such as thickening, centrifugation, and vacuum filtration, all extract water physically or mechanically from the sludge. However, the particle size and crystal structure are such as to limit the extent to which mechanical dewatering can be effective. The addition of dry flyash or other dry material, such as soil, accomplishes two things. It dries out the mixture by spreading the entrained water through a larger weight of solids and improves the particle size distribution so that closer packing can be accomplished. However, material that is physically stabilized in this manner is subject to erosion, rapid saturation, and leachability potential when exposed to rainfall.

Untreated--

Some FGD system designs do not include sludge treatment. The waste sludge is processed only to the point that it is thickened or dewatered before disposal or bled directly from the system to a pond.

Because of their inherent simplicity, thickeners and/or settling ponds are used in most scrubbing systems. They are used almost universally on the scrubber bleed stream to concentrate the scrubber solids. Thickeners are usually preferred to settling ponds because of efficiency in solids removal, flexibility in location, and smaller space requirements. However, thickeners are usually more expensive than ponds and require more operator attention and maintenance.

The primary advantages of a direct bleed to the pond include low capital cost and a minimum of mechanical equipment and operating manpower. Disadvantages include the difficulties and cost of excavating the dewatered material, the requirement for land area preferably near the plant, the need for careful dike construction and continued surveillance, the possible need for expensive liners, and the necessity in some locations to provide for human and animal exclusion.

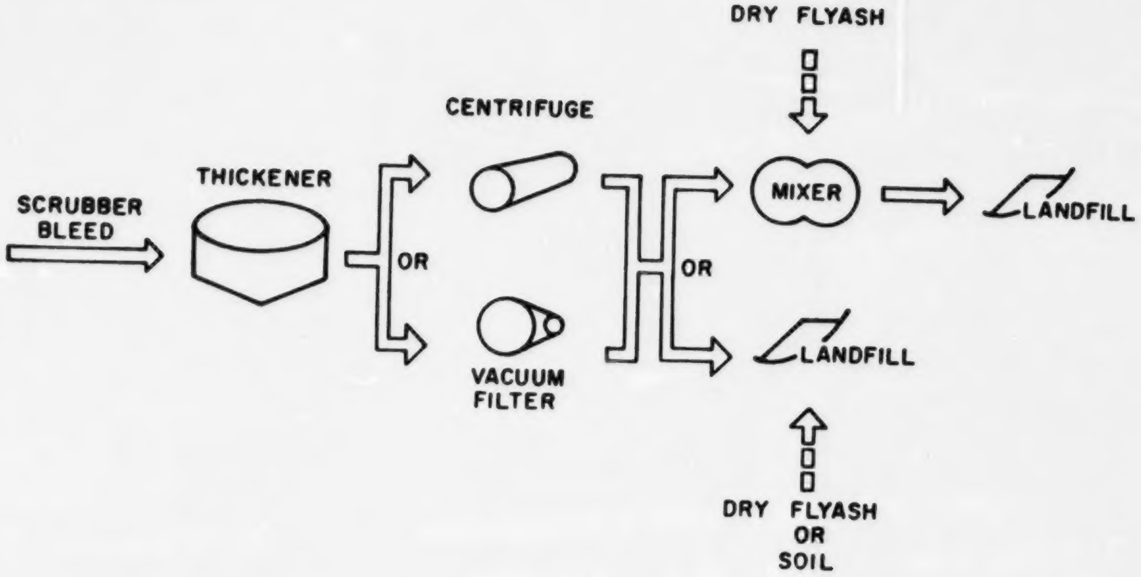

SCRUBBER BLEED
THICKENER
OR
CENTRIFUGE
VACUUM FILTER
OR
DRY FLYASH
MIXER
LANDFILL
LANDFILL
DRY FLYASH OR SOIL

Figure 27. Stabilization alternatives for blending non-alkaline flyash.

When used, vacuum filters or centrifuges generally follow thickeners or interim settling ponds to effect additional dewatering. Vacuum filters and centrifuges yield a better quality waste product which requires less space for disposal and is easily handled.

SECTION 10

SLUDGE DISPOSAL SITE TYPES

There are three basic FGD sludge disposal site types, the most common of which are ponding and landfilling. Stacking, as it applies to gypsum, is a third alternative. Sludge disposal site type refers to the final resting place for FGD waste following all handling and/or treatment stages.

10.1 GENERIC AND SPECIFIC CLASSIFICATIONS

Table 10 contains the generic and specific classifications developed to identify the sludge disposal site types contained in FGDIS. This table also provides common designs of the specific types listed.

10.1.1 Sludge Disposal Site Classification Descriptions

Lined/Unlined Pond--

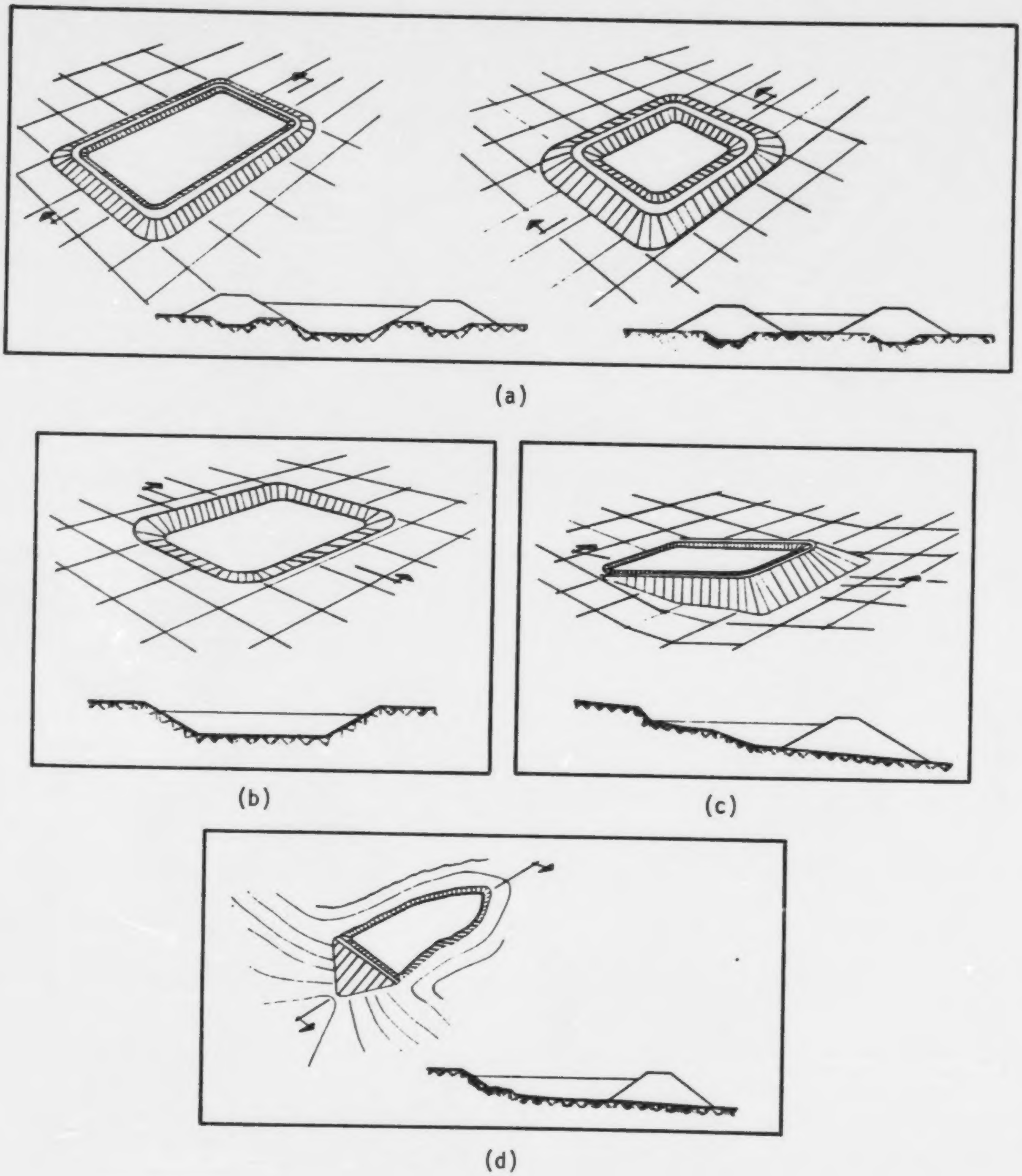
The most common sludge disposal site type is ponding. Ponds are either lined or unlined. A pond lining may consist of a plastic membrane, however, lined ponds used for conventional FGD processes are typically clay lined. The pond liner prevents leaching of the sludge constituents (sodium, magnesium, calcium trace elements) into the ground water.

Ponds are categorized as diked, incised, existing basin, side hill or cross valley. These are described below.

Diked pond--A diked pond is a pond contained within a perimeter embankment or dike. This form of pond construction requires a level or nearly level site. The dike may be constructed of materials excavated from below the existing grade at the pond site or it may be constructed above-grade from borrow sources as shown in Figure 28a. At some potential pond sites, excavation below the existing ground surface may be difficult due to shallow depths to groundwater or bedrock. In these cases, above-grade construction is necessary.

TABLE 10. SLUDGE DISPOSAL SITE TYPES

Generic	Specific	Common designs
Pond	Diked	Above grade Below grade
	Incised Existing basin	Abandoned surface mine Abandoned quarry
	Side hill Cross valley	Impoundment dam
Landfill	Heaped fill Side-hill fill Valley fill Deep mine fill Surface mine fill	
Stacking	Gypsum stack	Upstream method



(a)

(b)

(c)

(d)

Figure 28 . Examples of pond types included in FGDIS:
(a) diked; (b) incised; (c) side hill; (d) cross valley.

Incised pond--An incised pond is a pond contained in an excavation entirely below the existing ground surface level as shown in Figure 28b. This type of facility is attractive where groundwater and bedrock will not be encountered during excavation, where there is limited space for dike construction or when the excavated materials are either unsuitable for dike construction or valuable for some other purpose.

Existing basins--Existing basins such as abandoned surface mines and quarries are, in a sense, a variation of the incised pond. Existing basins differ primarily from incised ponds in that they are not constructed specifically for FGD sludge disposal. If available within a reasonable distance from the plant and approval can be obtained from the appropriate regulatory agencies, abandoned surface mines and quarries may provide suitable disposal sites.

Side-hill pond--This type of pond configuration lends itself to hilly terrain where a level site is not available for either diked or incised pond construction. The side-hill pond configuration takes advantage of the local terrain to provide one or two sides of the pond. An example of this type of construction is shown in Figure 28c. Depending upon the steepness of the natural slopes at the prospective pond site, it may be difficult to construct a large pond using side-hill construction unless the pond is long and narrow or the down hill dike is relatively high.

Cross-valley pond--A cross-valley pond is created by constructing a dam across a portion of a natural valley between the two valley walls. This type of pond configuration, similar to a typical water impounding dam, impounds both the natural drainage of the valley behind the dam as well as the FGD waste materials. Figure 28d shows a typical configuration. The design of this type of impoundment is more critical than the previously discussed pond configurations because it must provide for the controlled storage and discharge of the natural sources of valley water resulting from rainfall, surface runoff and existing springs, as well as adequately handle design flood flows.

Landfill--

Sludges that have been fixated or stabilized are usually (although not always) landfilled. Landfill sites may be heaped fill, side-hill fill, valley fill, or deep mine fill. These are described in the following subsections.

Heaped fill--The simplest configuration for dry disposal of FGD sludge is a heaped fill as shown in Figure 29a. This type of landfill is typically used in areas where the terrain is level. Groundwater pollution, slope stability and site preparation problems are usually minimal with this configuration. A heaped landfill operation, however, does not blend with the surrounding level terrain and is highly visible. For this reason, this method of disposal may be least preferred by regulatory agencies if other types of fill construction are possible.

Side-hill fill--In hilly or gently sloping terrain, side-hill construction is often possible as shown in Figure 29b. The fill may be constructed along the side of a hill or valley. Properly constructed, side-hill fills may blend well with the existing terrain and may provide valuable property when reclaimed. Site preparation and slope stability considerations are likely to be more complex than with heaped fills; however, they are not particularly severe problems.

Valley fill--The most common type of landfill in areas of hilly terrain is a valley fill, shown in Figure 29c. Since valleys are natural avenues of surface runoff and, in non-arid regions commonly have springs along the side slopes, control of surface water and groundwater is necessary. It is important to direct surface runnoff water under or around the fill to avoid impounding water and to help control erosion and surface runoff pollution. Similarly, springs to be covered by the fill must be collected and channelled to reduce leachate generation and slope instability. In general, site preparation is more complex with valley fills than with other landfill configurations.

Deep mine fill--A deep mine landfill is simply hauling the treated waste product to an abandoned mine, storing the material in the empty caverns. This strategy obviously can only used where such sites are easily accessible.

Stacking--

Stacking is only used for FGD systems that produce gypsum. The use of gypsum stacks for waste disposal has been demonstrated by the phosphate fertilizer industry where substantially greater amounts of the material are produced and must be disposed.

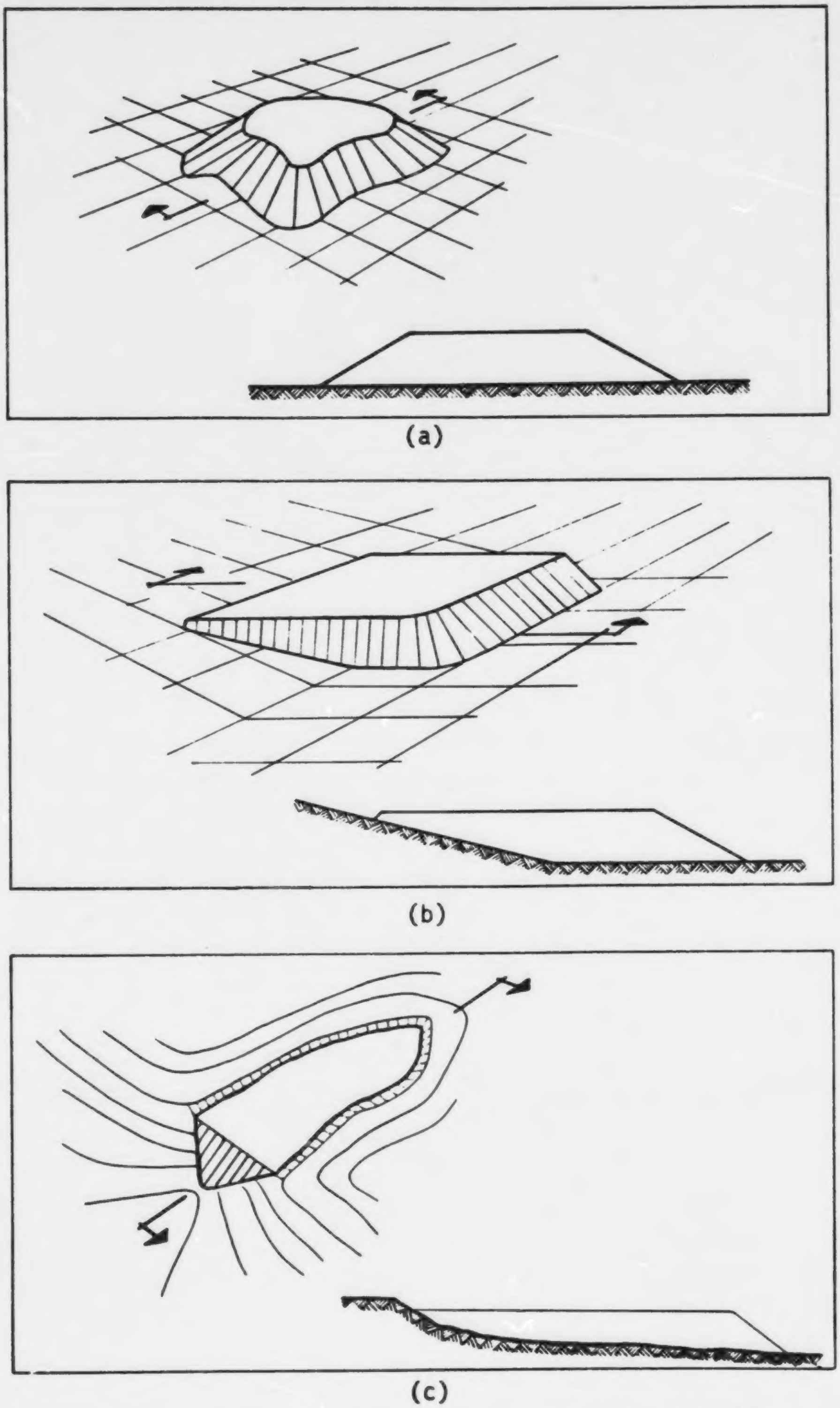
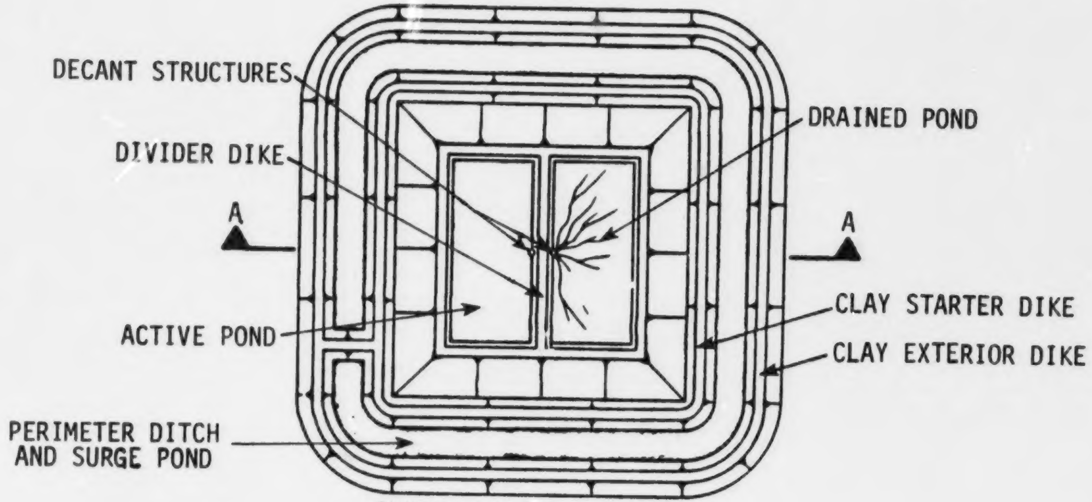


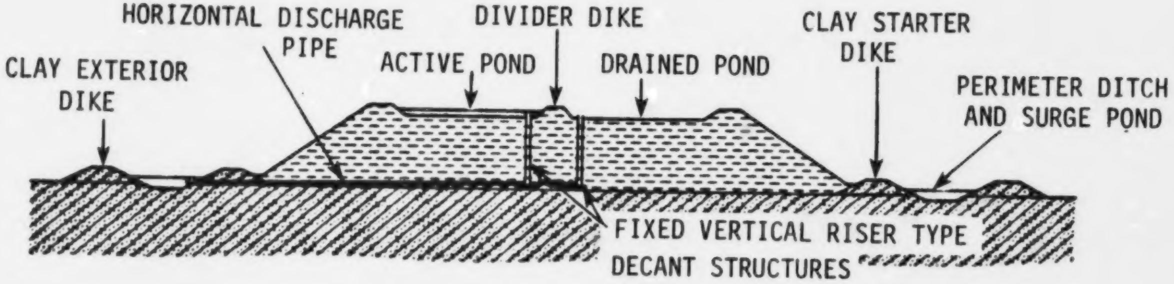
Figure 29. Examples of landfill types included in FGDIS: (a) heaped fill; (b) side-hill fill; (c) valley fill.

In "stacking", the gypsum is transported as a slurry to a specially designed pile which forms a stack as the material dewaters by gravity. The mineralogy, crystal geometry, and particle size of FGD gypsum provides settling, dewatering, and structural characteristics conducive to "stacking" methods of waste disposal.

The most economical gypsum stacking method is the upstream method of construction. In this method an earthen starter dike is first constructed to form a sedimentation pond and stacking area. Gypsum is then pumped to the sedimentation pond in slurry form, usually at 15 to 20 percent solids and allowed to settle and drain. Process water is decanted and returned to the plant. Once sufficient gypsum becomes sediment within the pond, gypsum is excavated with a dragline to raise the perimeter dikes of the stack with material thus dredged from the pond. A process water surge pond is built around the perimeter of the gypsum stack. The exterior dike forming the surge pond has sufficient freeboard to contain water stored on top of the gypsum stack in the event of activated spillage. Figure 30 shows a top view and a cross-section of a gypsum stack.


DECANT STRUCTURES
DRAINED POND
DIVIDER DIKE
A
A
ACTIVE POND
CLAY STARTER DIKE
CLAY EXTERIOR DIKE
PERIMETER DITCH AND SURGE POND

GYPSUM STACK SITE PLAN


HORIZONTAL DISCHARGE PIPE
DIVIDER DIKE
CLAY STARTER DIKE
CLAY EXTERIOR DIKE
ACTIVE POND
DRAINED POND
PERIMETER DITCH AND SURGE POND
FIXED VERTICAL RISER TYPE DECANT STRUCTURES

SECTION A-A GYPSUM STACK CROSS SECTION

Figure 30. Typical gysum stack design.

SECTION 11

BASIC REAGENT PREPARATION EQUIPMENT TYPES

This section summarizes the types of equipment used to prepare the process reagent for conventional FGD systems.

Limestone scrubbing systems include wet grinding equipment, specifically some version of the wet ball mill, for reagent slurry preparation. Lime and magnesium oxide FGD systems use various types of slakers to prepare the scrubbing slurry. Wet sodium carbonate, sodium carbonate spray dryer, and Wellman Lord systems have simple mix tanks for reagent solution preparation.

11.1 GENERIC AND SPECIFIC CLASSIFICATIONS

Table 11 contains the generic and specific classifications developed to identify the basic types of reagent preparation equipment types contained in FGDIS. Table 11 also provides common design variations of these types.

11.1.1 Reagent Preparation Equipment Descriptions

Ball Mill--

A ball mill as used in an FGD system is a piece of equipment used for grinding limestone to optimize the chemical reactivity of the material when slurried.

A basic ball mill consists of a rotating drum loaded with steel balls that crush the limestone by the action of the tumbling balls as the cylindrical chamber rotates.

The load of balls in a ball (or tube) mill occupy somewhat more than one-half the volume of the mill when the mill is stopped. In operation, the balls are picked up by the mill wall and carried nearly to the top, where they break contact with the wall and fall to the bottom to be picked up again. Centrifugal force keeps the balls in contact with the wall and with

TABLE 11. BASIC REAGENT PREPARATION EQUIPMENT TYPES

Generic	Specific	Common designs
Wet ball mill	Compartmented	2-compartment (tube mill) 3-compartment
	Hardinge	
Slaker	Detention	
	Paste	
	Batch	Agitated tank
	Ball mill	
Crusher-disintegrator		
Mix tank		Agitated tank

each other during the upward movement. While in contact with the wall, the balls do some grinding by slipping and rolling over each other, but most of the grinding occurs at the zone of impact, where the free-falling balls strike the bottom of the mill.

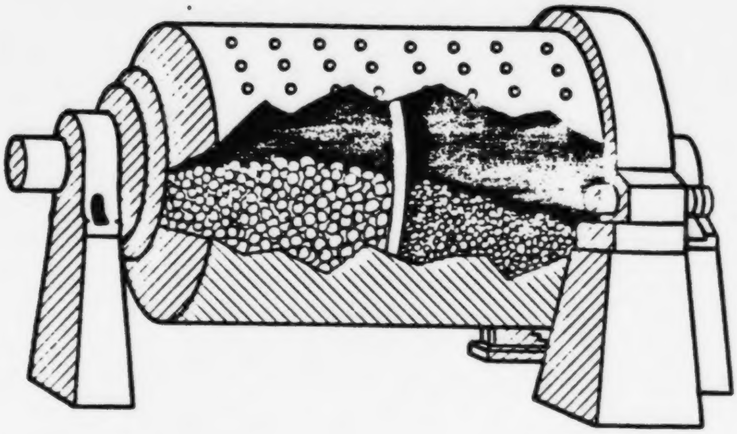
The faster the mill is rotated, the farther the balls are carried up inside the mill and the greater the power consumption. The added power is profitably used because the higher the balls are when they are released, the greater the impact at the bottom and the larger the productive capacity of the mill. However, when a critical speed is approached the balls are carried over and the mill is said to be "centrifuging". Little or no grinding is done when a mill is centrifuging, and operating speeds must be less than the critical.

Ball mills used in conventional FGD system designs fall into two categories. The long drum or tube mill variety is a compartmented type (Figure 31a). The Hardinge ball mill is noncompartmented and somewhat conical in shape (Figure 31b). In compartmented ball mills the primary grinding compartment near the feed inlet carries large grinding balls; one or more secondary compartments carry smaller balls for finer grinding.

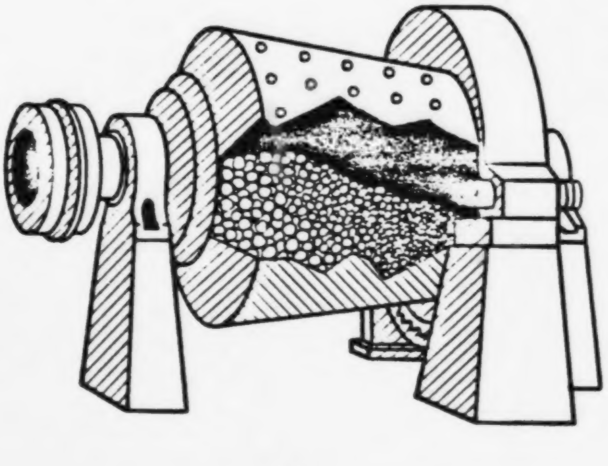
The Hardinge conical mill is similar to the cylindrical tube mills in that is consists of a drum rotating about its horizontal axis. Unlike the tube mill it has conical ends instead of straight ends. Ball segregation takes place and roughly proportions the energy to the work performed, the large balls assembling in the feed end of the mill and the smaller balls arranging themselves in decreasing sizes toward the discharge end.

Slaker--

A slaker is used to convert the dry calcium or magnesium oxide to calcium or magnesium hydroxide. The objective of lime or magnesium oxide slaking is to produce a smooth, creamy mixture of water and very small particles of alkali. A lime slaker mixes regulated streams of lime and water under the approximate agitation and temperature conditions to disperse soft hydrated particles as they form. Dispersion must be rapid enough to prevent localized overheating and rapid crystal growth of the hydroxide occurring in the exothermic reaction. However, the mixture must be held in the slaker long enough to permit complete reaction. The slaking of magnesium oxide follows



(a)



(b)

Figure 31. Wet ball mill type reagent preparation equipment: (a) compartmented ball mill; (b) Hardinge ball mill.

the same principle. However, the initial reaction is not so vigorous so that less heat is generated.

Figure 32a shows a detention slaker. Quicklime and water are fed to the slaker in specific proportions in order to produce a slurry containing 20 to 30 percent solids. The mixture is agitated with a high-speed propeller mixer. From the agitated chamber, slurry flows into a quiet section where grit settles out. Degritted slurry is then diluted with additional water and flows to a stabilization tank. Grit is continuously removed from the quiet section by means of a mechanical scaper. It is rinsed with a small stream of water and discarded. In a detention slaker, water is added to each chamber. The amount of water is manually proportioned by trial and error to achieve the best results with the lime being used. Slurry is usually retained in a detention slaker 20 to 30 min at a temperature of about 167°F.

Figure 32b shows a paste slaker. The paste slaker operates on the pug mill principle, kneading a thick mixture of lime and water. Feeds are proportioned to produce a putty-like mixture containing about 40 to 50 percent solids. The mixture is blended in a narrow trough by paddles that rotate on horizontal shafts. The thick slurry continuously overflows the end of the trough into a dilution chamber, where more water is added and grit is separated, rinsed, and discarded. Slurry is retained in a paste slaker for only 5 to 10 min. The slaking temperature is usually about 185 to 194°F.

Some manufacturers offer general purpose mixing equipment as a substitute for a lime slaker. Simple tanks equipped with agitators (Figure 32c) have been used in some applications. With this equipment, quicklime and water are fed into the tank and the mixture is stirred briskly. Although a "batch slaker" of this type is a simple device, it invariably produces a poor quality slurry. Even with high-energy agitation, slaking may not be uniform. Hard, crystaline lime particles are formed, slaking is usually incomplete, and part of the lime is lost as a hard scale that forms in the tank. The slurry is usually very erosive and reacts slowly in the FGD system. This type of slaker is much larger than a continuous slaker and requires more operating and maintenance labor.

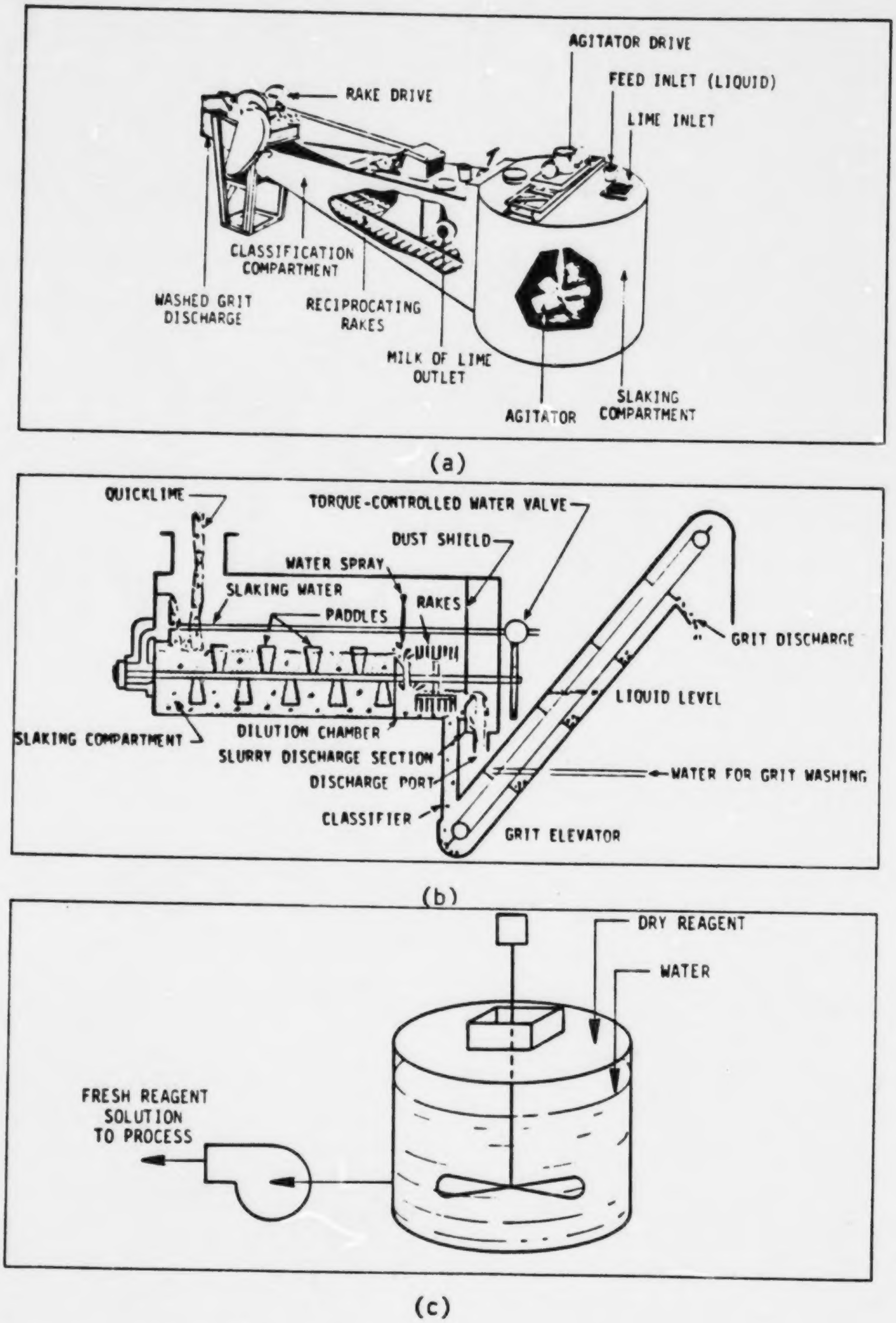

AGITATOR DRIVE
FEED INLET (LIQUID)
RAKE DRIVE
LIME INLET
CLASSIFICATION COMPARTMENT
WASHED GRIT DISCHARGE
RECIPROCATING RAKES
MILK OF LIME OUTLET
AGITATOR
SLAKING COMPARTMENT
(a)
QUICKLIME
TORQUE-CONTROLLED WATER VALVE
DUST SHIELD
WATER SPRAY
SLAKING WATER
RAKES
PADDLES
GRIT DISCHARGE
LIQUID LEVEL
SLAKING COMPARTMENT
DILUTION CHAMBER
SLURRY DISCHARGE SECTION
DISCHARGE PORT
WATER FOR GRIT WASHING
CLASSIFIER
GRIT ELEVATOR
(b)
DRY REAGENT
WATER
FRESH REAGENT SOLUTION TO PROCESS
(c)

Figure 32. Slaker type reagent preparation equipment included in FGDIS: (a) detention slaker; (b) paste slaker; (c) batch slaker (mix tank).

Another potential lime slurry preparation system is the "ball mill slaker," which wet grinds the lime. The resulting slurry consists of calcium hydroxide, grit and scale compounds finely ground and suspended in water. The advantage of this process is that close chemical control is unnecessary. Any type of water can be used, the slaking temperature is unimportant, and even the poorest grades of lime can be treated. Any limestone that might be in the feed material is also present in the slurry and represents available alkali. Disadvantages of the ball mill include high initial cost, very high operating costs, formation of an abrasive slurry, and operation so noisy that the equipment is usually housed in a separate building.

Crusher-Disintegrator--

Another type of reagent preparation equipment that has been applied to carbide lime systems is the crusher-disintegrator. In crusher-disintegrators, the absorbent is added as a 30 percent solids slurry. Any tramp solids or other foreign matter in the carbide lime slurry are removed by the crusher-disintegrator while the unit supplies lime of the proper consistency to the reaction supply tank.

Crusher-disintegrators have not been widely used for FGD systems and none are currently operating. They are therefore not emphasized here.

Mix Tank--

Sodium carbonate and other soluble reagents are prepared by simply adding the material and water to a tank equipped with an agitator (Figure 32c). The optimum concentrations of the reagent is maintained by balancing the water and dry reagent addition. The concentration of the solution may be controlled by maintaining a predetermined pH level. Heaters, hot water, or low pressure-low temperature steam systems are often used to accelerate soluble reagent preparation.

SECTION 12

BASIC PUMP TYPES

12.1 GENERIC AND SPECIFIC CLASSIFICATIONS

Pumps are used in various areas of FGD systems. The primary pumps of interest are the slurry (or soluble reagent) recycle pumps. These are the pumps that are subject to the most critical environment and constitute the highest maintenance concern of all pumps used. There are, however, other important pumps such as those that supply service and makeup water, pond return water pumps, and those that transfer, such as thickener underflow, and waste slurry transfer pumps, etc. The types of pumps used in FGD systems are described in the text that follows.

12.1.1 Pump Classification Descriptions

This section describes the various types of pumps used in conventional FGD systems. Pumps may be classified into two generic groups: displacement and nondisplacement (centrifugal). There are a number of specific types that fall into these two groups as shown in Table 12. Common designs of each of the specific types along are also shown in this table.

Displacement--

Reciprocating pumps--Reciprocating pumps are characterized by a pumping member that moves back and forth on an axis (i.e., a single plane). There are three common reciprocating pump designs: piston, plunger, and diaphragm. In general the action of the liquid transferring mechanism of a reciprocating pump is the same; a cylindrical piston, plunger, or round diaphragm moved back and forth in a chamber. Three moving elements are necessary for operation of a reciprocating pump; these are the piston, plunger or diaphragm; the inlet valve; and the outlet valve. Reciprocating pumps require considerable maintenance but can produce the highest pressures. They characteristically deliver a pulsating liquid stream, which may or may not be a disadvantage.

TABLE 12. BASIC PUMP TYPES

Generic	Specific	Common designs
Displacement	Reciprocating	Piston Plunger Diaphragm
	Rotary	Gear Vane
	Screw	Single-rotor moyno
Nondisplacement	Centrifugal	Single-admission intake
	Vertical turbine	In-line Wet pit Dry pit Sump

Figure 33a shows the working cycle of piston and plunger type pumps, as well as a diaphragm type reciprocating pump.

Diaphragm pumps perform similarly to piston and plunger pumps. Their construction differs in that the reciprocating driving member is a flexible diaphragm rather than a piston or plunger, to perform pumping operation. The chief advantage of this arrangement is the elimination of all packing and seals exposed to the liquid pumped. In FGD systems, some thickener underflow pumps are of diaphragm variety. An example diaphragm pump used for slurry service is shown in Figure 33. This particular example is pneumatically operated.

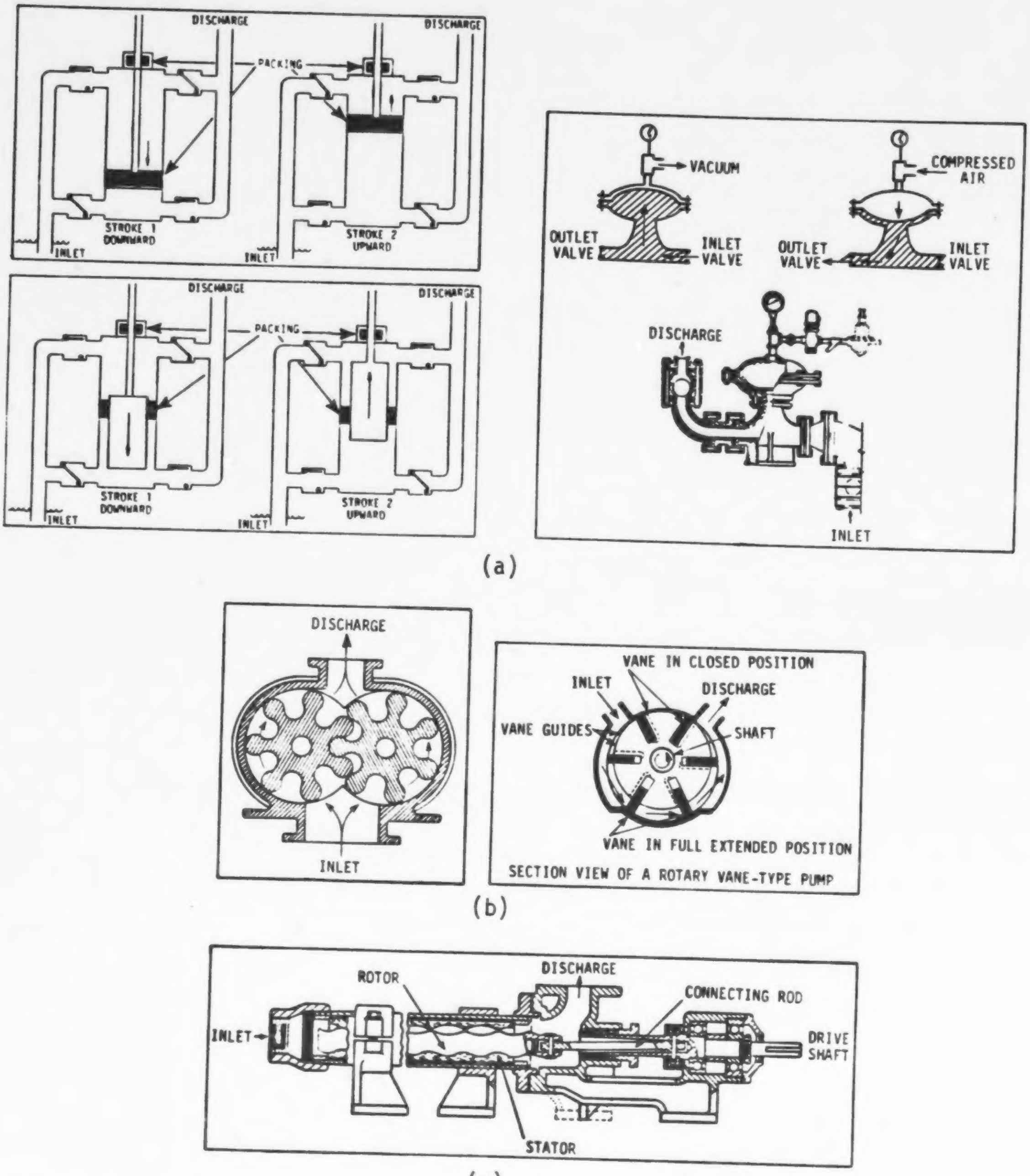
Rotary Pumps

In rotary pumps mechanical displacement of the liquid is produced by rotation of one or more members within a stationary housing. There are two common designs of rotary pumps: gear-type, and vane-type (Figure 33b). The gear-type pump is a power-driven unit having two or more intermeshing gears or lobed members enclosed in a housing. In the rotary-vane-type pump operation is based on the principle of increasing the size of the cavity to form a vacuum, allowing the space to be filled with fluid, and then forcing the fluid out of the pump under pressure by diminishing the volume. Rotary pumps are not designed to handle liquid which contains grit or other abrasive materials, therefore, rotary pumps are rarely used in FGD systems.

Screw pumps--Screw pumps differ from rotary pumps in that the flow through the pump is axial instead of circumferential like the rotary pumps. The liquid is carried between screw threads on one or more rotors and is displaced axially as the screws rotate and mesh. The unique axial flow pattern and low internal velocities give screw pumps a number of advantages in many applications where other pumps cannot be used.

Screw pumps are classified into single- or multiple-rotor types. In a single-rotor screw pump, the rotor thread is eccentric to the axis of rotation and meshes with internal threads of the stator (rotor housing or body).

In utility FGD systems, screw pumps are used for reagent feed pumps. Screw pumps can easily handle a concentrated (30 to 40 percent) slurry of lime or limestone.



DISCHARGE
DISCHARGE
PACKING
STROKE 1 DOWNWARD
STROKE 2 UPWARD
INLET
INLET
DISCHARGE
DISCHARGE
PACKING
STROKE 1 DOWNWARD
STROKE 2 UPWARD
INLET
INLET
VACUUM
COMPRESSED AIR
OUTLET VALVE
INLET VALVE
OUTLET VALVE
INLET VALVE
DISCHARGE
INLET
DISCHARGE
INLET
VANE IN CLOSED POSITION
INLET
DISCHARGE
VANE GUIDES
SHAFT
VANE IN FULL EXTENDED POSITION
SECTION VIEW OF A ROTARY VANE-TYPE PUMP
ROTOR
DISCHARGE
CONNECTING ROD
INLET
DRIVE SHAFT
STATOR

(a)

(b)

(c)

Figure 33. Displacement pumps: (a) reciprocating; (b) rotary; (c) screw (moyno).

Nondisplacement--

The only nondisplacement pump used for utility FGD system applications is the centrifugal pump. A centrifugal pump consists primarily of an impeller rotating within a casing (Figure 34). The impeller consists of a number of blades, either open, semi-open, or enclosed (shrouded), mounted on a shaft that projects outside the casing. The open type is suited for liquids that contain no solids or foreign matter. Examples of these are also shown in Figure 34.

Common designs of centrifugal pumps are single-admission and double-admission intake. Only the single-admission design is applicable to FGD systems. Figure 34 shows single-admission type centrifugal pump as distinguished from the double-admission type.

In lime/limestone FGD systems, centrifugal pumps are widely used for water and slurry handling applications. These include makeup water pumps, recirculation pumps, fresh slurry feed pumps, thickener overflow/underflow pumps, and mist eliminator wash water pumps. Out of these, the recirculation pumps are the largest pumps with capacities ranging from 5,000 to 15,000 gpm. They receive slurry directly from the bottom of the scrubber or from a reaction hold tank. The discharge slurry is continuously recirculated through the scrubber/absorber. These pumps usually operate at a constant speed, supply constant liquid flow, and are quiet in operation. The pumps are powered either directly or via v-belt drive.

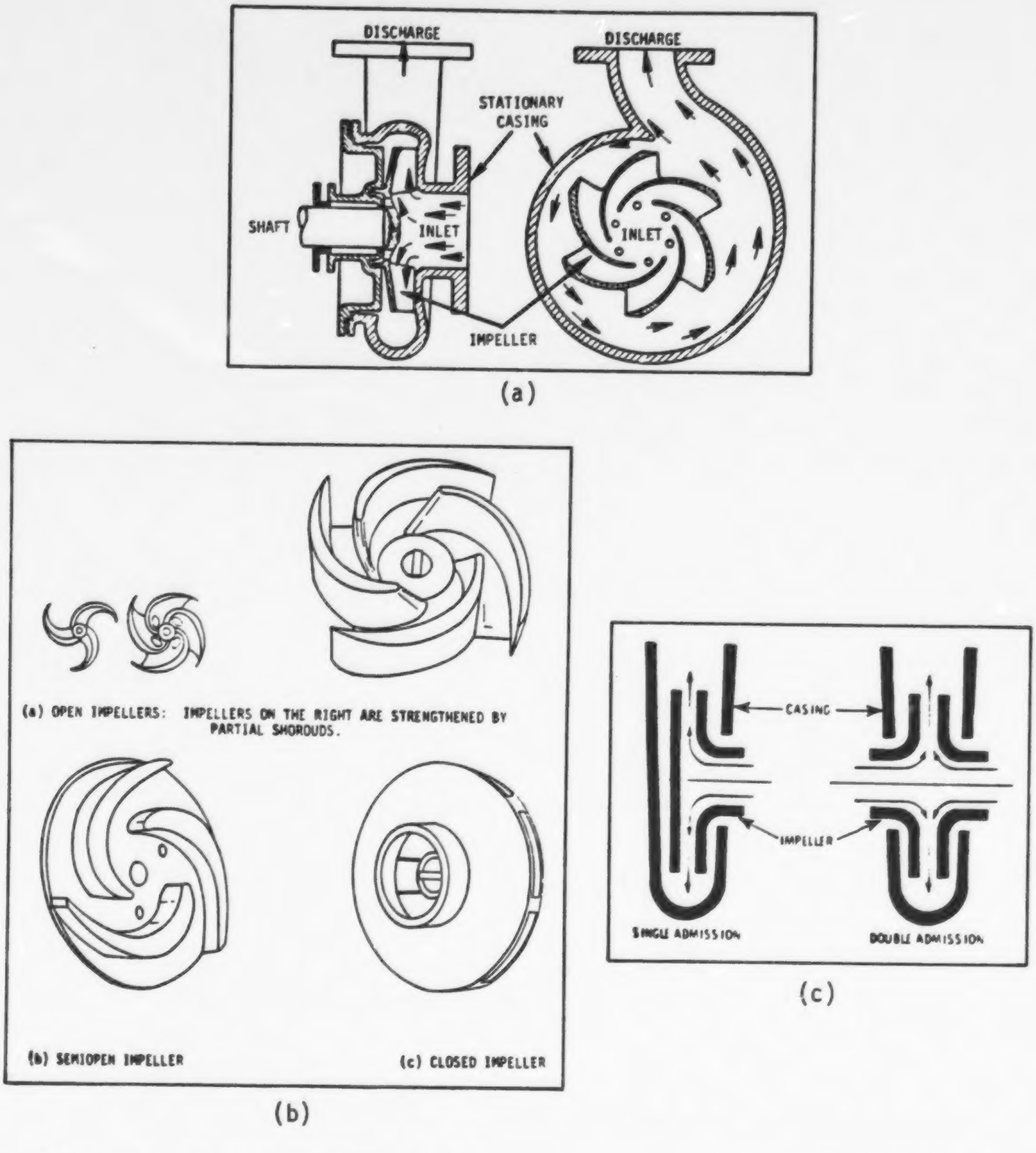

DISCHARGE
DISCHARGE
STATIONARY CASING
SHAFT
INLET
INLET
IMPELLER
(a)
(a) OPEN IMPELLERS: IMPELLERS ON THE RIGHT ARE STRENGTHENED BY PARTIAL SHOROUDS.
(b) SEMIOPEN IMPELLER
(c) CLOSED IMPELLER
(b)
CASING
IMPELLER
SINGLE ADMISSION
DOUBLE ADMISSION
(c)

Figure 34. Centrifugal pump: (a) cross section of a typical centrifugal pump; (b) common impeller types; (c) single-admission type impeller as distinguished from a double-admission design.

SECTION 13

BASIC VALVE TYPES

This section describes the basic types of valves used in FGD systems. Valves are used throughout FGD systems not only to regulate the flow of fluids but also to isolate piping or equipment for maintenance/repair without interrupting other connected systems. This helps to provide for continuous operation and minimal downtime.

13.1 GENERIC AND SPECIFIC CLASSIFICATIONS

Table 13 lists the generic and specific classifications developed to identify the basic valve types contained in FGDIS. The generic classifications of valves are: ball, butterfly, check, gate, globe, pinch, and plug valves. The following is a description of these basic valve types along with advantages and disadvantages with respect to their use in FGD systems.

13.1.1 Valve Classification Description

Ball Valve--

Ball valves consist of a spherical chamber within which a ball with a porthole drilled through the center acts as the valving element (Figure 35). Ball valves are classified as free or fixed ball designs. In free- ball designs the ball is free to move axially. The pressure differential across the valve forces the ball in the closed position against the downstream seat and the latter against the body. In fixed-ball designs the ball rotates on stem extensions with bearings sealed with O-rings (Figure 35a). Ball valves are characterized by a good straight line of flow (low pressure drop) and are capable of handling a medium to high pressure. Ball valves are used mainly for on-off service and are not recommended for throttling service.

TABLE 13. BASIC VALVE TYPES

Generic	Specific
Ball	Free ball Fixed ball
Butterfly	Wafer Lug Flanged
Check	Lift Ball Swing
Gate	Wedge Double disc
Globe	
Pinch	
Plug	

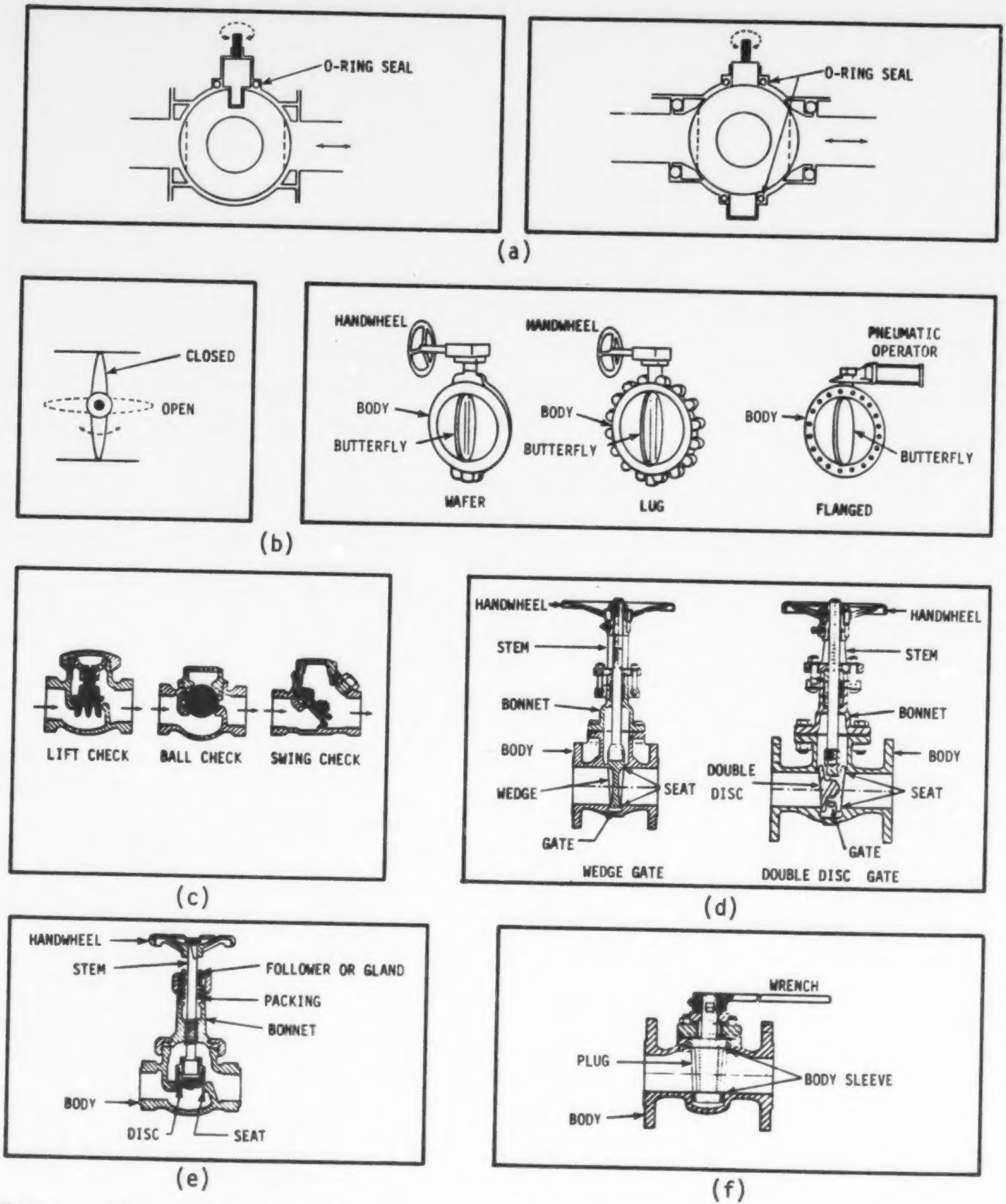

O-RING SEAL
O-RING SEAL
(a)
CLOSED
OPEN
HANDWHEEL
BODY
BUTTERFLY
WAFER
HANDWHEEL
BODY
BUTTERFLY
LUG
PNEUMATIC OPERATOR
BODY
BUTTERFLY
FLANGED
(b)
LIFT CHECK
BALL CHECK
SWING CHECK
(c)
HANDWHEEL
STEM
BONNET
BODY
WEDGE
SEAT
GATE
WEDGE GATE
HANDWHEEL
STEM
BONNET
BODY
DOUBLE DISC
SEAT
GATE
DOUBLE DISC GATE
(d)
HANDWHEEL
STEM
FOLLOWER OR GLAND
PACKING
BONNET
BODY
DISC
SEAT
(e)
WRENCH
PLUG
BODY SLEEVE
BODY
(f)

Figure 35. Valve types included in FGDIS: (a) ball valves; (b) butterfly valves; (c) check valves; (d) gate valves; (e) globe valve; (f) plug valve.

Butterfly Valve--

A butterfly is a simple plate that opens or closes by turning the plate parallel or perpendicular to the fluid flow. Figure 35b shows a simplified diagram of a butterfly valve as it appears from the top. As the plate is opened, the fluid passes around the plate and through the valve. The rate of flow is governed by the degree to which the plate is opened. There are three specific types of butterfly valves: wafer, lug, and flanged. They are easily identified by their characteristic housing/body used in mounting the valve (Figure 35b). Butterfly valves offer the advantages of easy operation, small space requirements, absense of sliding parts, low head loss, drip-tight shutoff at moderate pressure, suitability for throttling, quick opening and closing, and high reliability.

Butterfly valves are used as on-off control valves for slurry service lines and in recirculation slurry pump discharge piping. They range in size from 2 to 20 inches and can handle flow rates up to 10,000 gpm. In the throttled position, however, butterfly valves can damage downstream piping because their discharge flow is asymmetric.

Check Valve--

Check valves ensure that liquid will flow in only one direction. A check valve is opened by the pressure of the liquid in the desired direction; when the flow stops or tends to reverse, the valve automatically closes by gravity or by a spring pressing against the valving element. Specific types of check valves are shown in Figure 35c. Lift check valves are for use in vertical lines where the flow is normally upward. Ball check valves, on the other hand, are for use in horizontal lines. Swing check valves are recommended for use in low-flow pipelines and in short pump discharge lines.

Check valves are normally unsuited for sludge applications and sometimes cause water hammer problems if lines are subject to pressure surges (e.g., starting and stopping of pumps).

Gate Valve--

In a gate valve the diameter of the opening through which the liquid passes is nearly the same as that of the pipe, and the direction of flow does not change. The flow area is controlled by the vertical movement of the gate across the port opening of the stationary orifice plate. The gate is tapered and fits into a tapered seat; when the valve is opened, the gate rises into the bonnet, completely out of the path of the fluid.

The specific classifications of gate valves are single wedge (knife) and double disc. Common designs of these are non-rising stems or rising stems, listed in order of decreasing exposure of the stem threads to the fluid handled. Figure 35d shows single wedge and double disc types with rising stems.

Advantages of gate valves include unobstructed flow with low head loss in the wide-open position, resistance to leakage and high pressure, and inherent wiping action to keep the gate free of adhering materials. Disadvantages include the complexity of the mechanisms often required for wedging the gates against the seats, and the wear caused by sliding surfaces. These factors make gate valves unsuitable for continuous regulation or frequent on-off operation.

Wedge (knife) gate valves are used for quickly starting and stopping flow and are recommended for service involving slurry and sludge.

Globe Valve--

Globe valves (so called because in the earliest designs the valve body was round) the liquid passes through a restricted opening and changes direction several times. An example globe valve is shown in Figure 35e. As the stem is raised, the plug is guided up into the bonnet allowing the liquid to pass around the plug and through the valve.

Globe valves are designed as either inside-screw rising stem or outside-screw rising stem. Small valves generally are of the inside-screw type, while the larger sizes--the outside--screw type is preferred. Globe valves provide drip-tight shutoff, are suitable for throttling services, and require little maintenance because of relatively few moving parts.

Globe valves are not used in slurry or sludge service because the seats are too susceptable to damage by solids. Globe valves are recommended to control service water, mist eliminator wash, and miscellaneous water flows.

Pinch Valve--

The pinch valve consists of a flexible hose-like tube through which fluid flows at various rates depending on how much the tube is "pinched" by the valving element (pairs of movable and stationary bars). Units are suitable for throttling and provide bubble-tight shutoff even on entrapped solids. In the fully-open positions, unrestricted flow paths are available giving rise to low pressure drops. Because of this, pinch valves are recommended for slurry and sludge services where solids have a tendency to plug the other more complicated valves. However, pinch valves are subject to wear due to the pinching action on the flexible tube.

Plug Valve--

Plug valves incorporate truncated cones, drilled with transverse flow passages. These are rotated relative to the flow direction to vary the effective flow orifice size. The plugs rotate on rather than lift from their seats. An example plug valve is shown in Figure 35f.

Plug valves are recommended for sludge and slurry services because they are easily cleared when obstructed and may be operated frequently without appreciable wear. This is due to the fact that they are normally self-lubricating and the ground seat is protected when the valve is open. Plug valves are normally used for isolation service in water and/or slurry lines. Eccentric plug valves, in which the plug wipes past the seal and is clear of flow in the open position, have excellent results in slurry service.

SECTION 14

BASIC DAMPER TYPES

Dampers are used to control, shut off or isolate, and bypass the flow of flue gases in FGD systems. Whole systems or individual modules (or scrubbing trains) may be isolated by the use of dampers. They are mainly used at the inlet duct to the module, the outlet duct from the module, and the bypass duct (for those installations capable of bypassing). Dampers may be used individually or in combinations with others and be equipped with seal air systems to minimize leakage.

14.1 GENERIC AND SPECIFIC CLASSIFICATIONS

Table 14 lists the generic and specific classifications along with common design types of dampers used in FGD systems. As given in Table 14, the generic classifications of dampers are: louver, guillotine, butterfly, and blanking plate dampers.

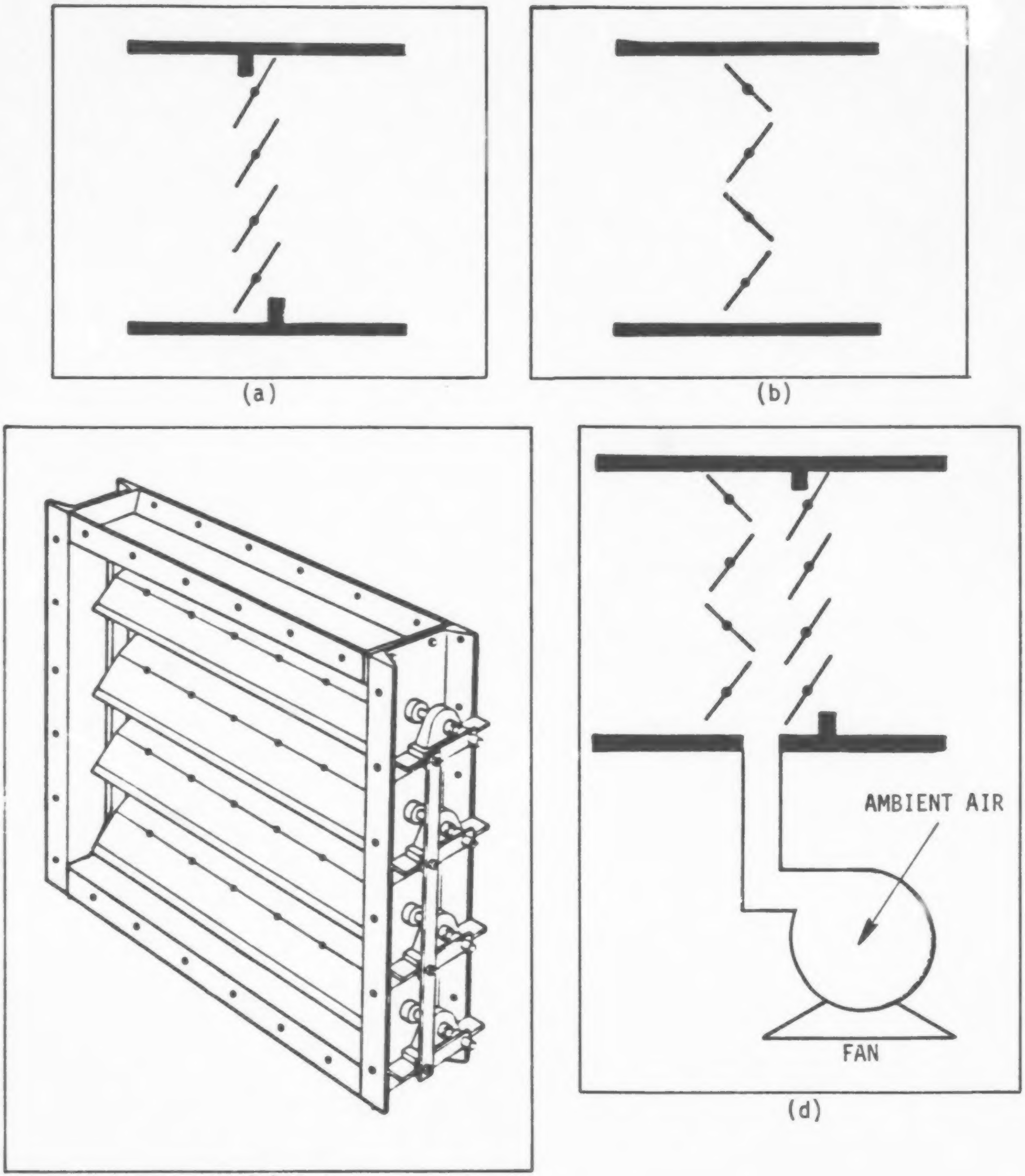
14.1.1 Damper Classification Descriptions

Louver--

Louver or multi-blade dampers may be either opposed blade or parallel blade designs (Figures 36a and 36b). An overall view of a parallel- blade, multi-louver damper is shown in Figure 36c. Parallel blade louver dampers can be closed tight but offer little modulation ability. Opposed blade louver dampers offer excellent modulation ability, but cannot be closed as tight as parallel blade louver dampers. Louver dampers may be used to regulate and isolate flue gas flow. For isolation, two dampers are used together and sealed by pressurizing the chamber formed by the ductwork between the dampers with a seal air fan (Figure 36d). A single damper may be used for gas flow regulation.

TABLE 14. BASIC DAMPER TYPES

Generic	Specific	Common designs
Louver	Parallel blade multilouver Opposed blade multilouver	Single louver Double louver Double louver/seal air
	Parallel/opposed blade multilouver	Double louver Double louver/seal air
Guillotine	Top-entry guillotine Top-entry guillotine/seal air Bottom-entry guillotine Bottom-entry guillotine/seal air	
Butterfly		
Blanking plate		



(a) (b) (c) (d)

Figure 36. Louver dampers: (a) parallel blade multi-louver; (b) opposed blade multi-louver; (c) parallel blade multi-louver damper view showing linkage; (d) simplified multi-louver diagram with seal air.

Guillotine--

A guillotine damper may be a top-entry or bottom-entry design, with or without seal air (Figure 37). Guillotine dampers for scrubber isolation may be equipped with a seal air blower singly or in a double-bladed (as with the multi-louver shown in Figure 36d) to pressurize the sealing space and thus ensure against flue gas leakage past the damper.

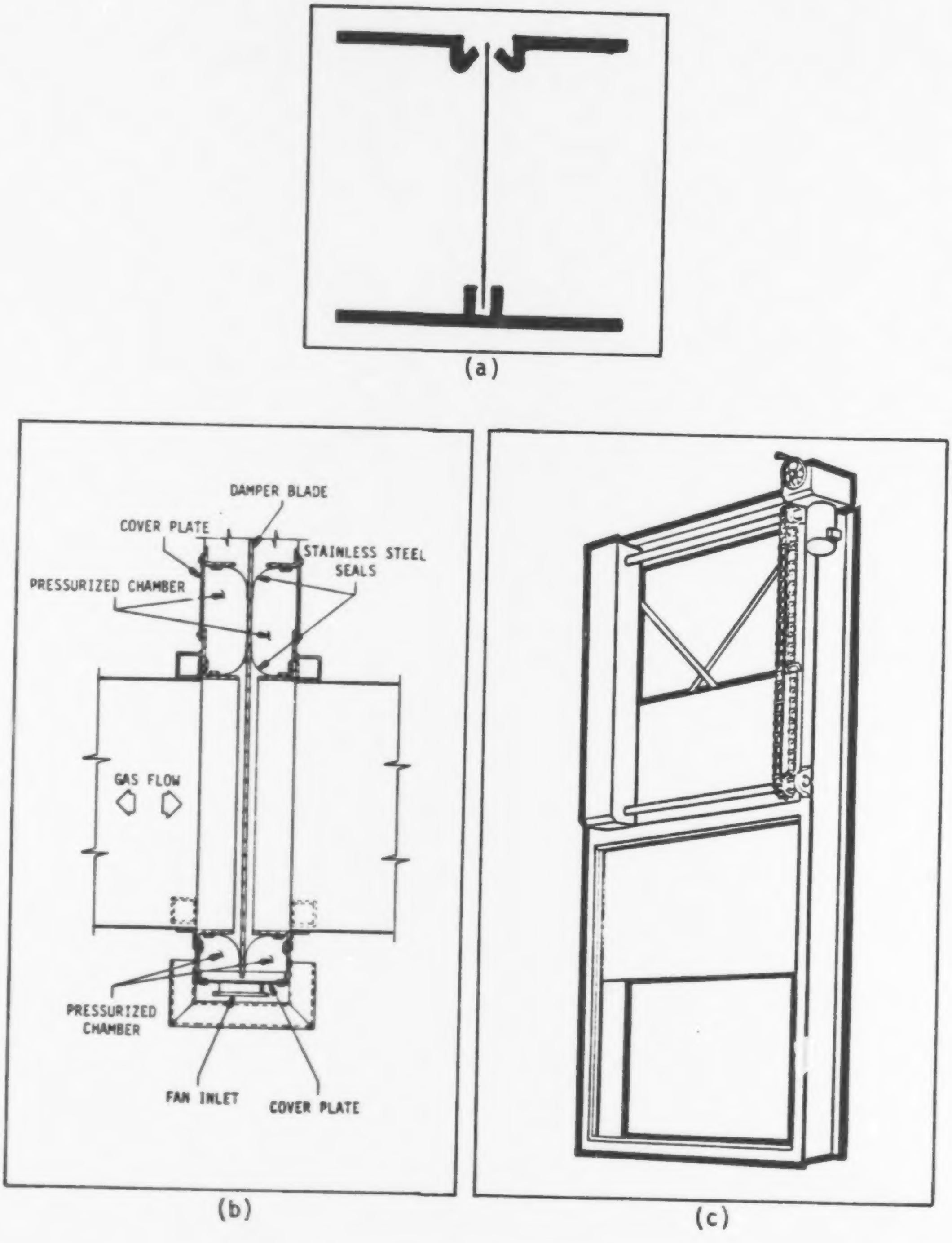
Butterfly--

Butterfly dampers are often used for secondary duct runs such as bypass or reheater duct applications (Figure 38). Butterfly dampers are mounted by a center shaft which crosses the duct and about which the damper plate rotates from a plane parallel to the gas flow (open) to a plane perpendicular to the gas flow (closed). Butterfly dampers are more often used to regulate gas flow although they have been used for opening and closing off ducts and scrubbing modules.

Blanking plate--

The most basic damper is the simple blank-off plate. Blanking plates are essential when modules must be isolated for protection of the maintenance crew. Should it become necessary for persons to enter any section of the ductwork or scrubber, the blanking plate can insure isolation. When used in conjunction with positive ventilation air purge, the blanking plates protect the safety of personnel.

Blanking plates are similar to guillotine dampers in that they cut across the duct opening, however, the track design for a blanking plate is designed only to guide the plate as it is put in place and bolted down.

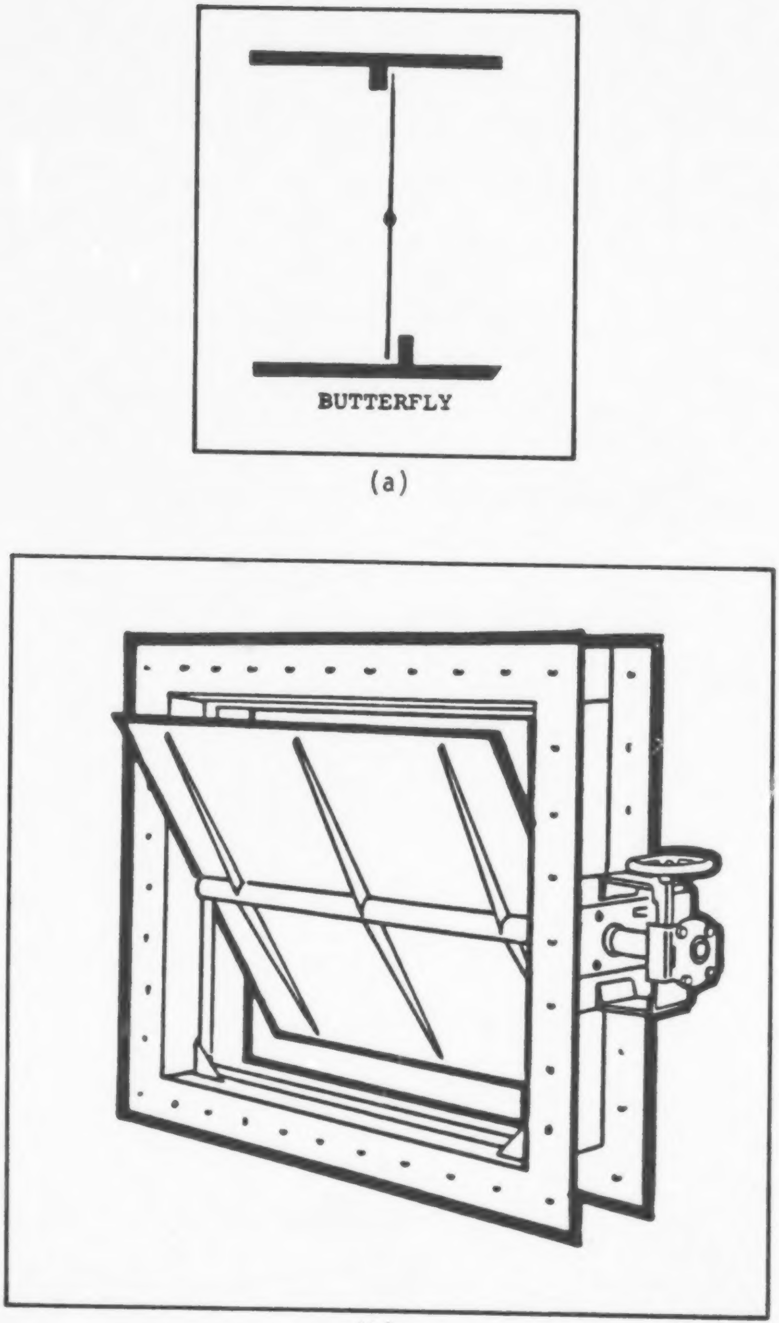

DAMPER BLADE
COVER PLATE
STAINLESS STEEL SEALS
PRESSURIZED CHAMBER
GAS FLOW
PRESSURIZED CHAMBER
FAN INLET
COVER PLATE

(a)

(b)

(c)

Figure 37. Guillotine damper: (a) simplified cross-section view of a guillotine damper; (b) guillotine isolation damper using seal air; (c) top-entry type guillotine damper showing operation.



(a)

(b)

Figure 38. Butterfly damper: (a) simplified cross-section view of a butterfly damper; (b) guillotine damper showing hand operator.

SECTION 15

BASIC TYPES OF CONSTRUCTION MATERIALS

The generic and specific materials classifications which are described in the paragraphs that follow represent a summary of the types of construction materials used in conventional utility FGD systems.

15.1 GENERIC AND SPECIFIC CLASSIFICATIONS

A systematic grouping of the various construction materials used in wet FGD systems is shown in Table 15. The materials are grouped into two basic types: (1) base metals and (2) plastics, ceramics, and protective linings. Within each group the materials are further categorized according to generic, specific, and common or trade name classifications. The generic classification of base metals includes carbon steels, stainless steels, and high-grade alloys; the plastics, ceramics, and protective linings are grouped generically as organic and inorganic materials. The specific classifications designate distinct types of materials within each generic grouping. The common or trade name classifications designate special or proprietary materials within each specific grouping.

15.1.1 Base Metals - Construction Material Classification Descriptions

Carbon Steel--

Carbon steel is the most common construction material in scrubbing systems. Carbon steel may be used for scrubber shells, pumps, fans, piping, reheaters, thickeners, stack flues, and virtually every component of a scrubbing system except for spray nozzles and mist eliminators. Unlined carbon steel can be utilized where alkaline conditions (pH >7) are maintained, such as in lime/limestone storage silos or in the piping that carries makeup slurry to the absorber section of the system. Where unlined metal is exposed to sulfurous and sulfuric acids, either condensed from the gas stream or as

TABLE 15 . BASIC TYPES OF CONSTRUCTION MATERIALS

Generic	Specific	Trade or common name
Base metals		
Cast iron	Gray cast iron Ductile iron	Duriron
Carbon steel	A-285 AISI 1110	
	High strength low alloy [HSLA]	Cor-Ten
Stainless steel (wrought)	Ferritic	Type 430 E-Brite 26-1
	Austenitic	Type 304 Type 304L Type 316 Type 316L Type 317 Type 317L
Stainless steel (cast)	Austenitic	CD-4 MCU
High alloy (wrought)	Iron base/nickel-chromium-copper-molybdenum	Carpenter 7 Carpenter 20 Alloy 904L
	Iron base/chromium-molybdenum-nickel-copper	Climax 18-2
	Nickel base/chromium-iron-copper-molybdenum	Incoloy 825 Hastelloy G
	Iron base/nickel-chromium-molybdenum	Haynes 20 Je[illegible]op JS 700 [illegible]heny AL-6X Nitronic 50
	Iron base/chromium-molybdenum-nickel	Allegheny 29-4
	Nickel base/chromium-iron-molybdenum	Hastelloy C Hastelloy C-276 Hastelloy C-4 Inconel 625
High alloy (cast)	Iron base/nickel-chromium molybdenum	IN-862
	Nickel alloy cast iron	NI-hard type 4
Other metals	Titanium Zirconium 702 Brass Bronze	

(continued)

TABLE 15 (continued)

Generic	Specific	Trade or common name
Plastics, ceramics, and protective linings		
Organic	Natural rubber	Black natural rubber
	Synthetic rubber	Neoprene LS-576 Chlorobutyl Telex 200, Hypalon Butyl 40
	Polyester	
	Mica flake-filled polyester	Flakeline 151 Flakeline 252 Resista-flake 1251 Rigiflake 489
	Alumina flake-filled polyester	
	Glass flake-filled polyester	Flakeline 103 Resista-flake 1103, 1151, 1150 Protecto-flake 500 & 550 Rigiflake 4850 & 4855 Dudick
	Fiber-reinforced polyester	
	Mat-reinforced polyester	Ceilcrete 2500AR
	Vinyl ester	
	Inert flake-filled vinyl ester	Plasite 4004, 4004-S 4005, 4020 & 4030
	Glass flake-filled vinyl ester	
	Epoxy	Flakeline E
	Mat-reinforced epoxy	Coroline 505 & 505 AR Rigiflake 413 GS Plasite 7122, 7122H
	Fluoroelastomer	CXL-2000 Flakeline 282-X
	Bitumastic	
	Coal tar epoxy	Carbomastic 14, Martex 200
	Non-asphaltic mastic	Stackfas
	Polyvinyl chloride	
	Polyethylene	
	Polypropylene	
	Polyphenylene	Noryl grade EN-265
Inorganic	Prefired brick/shapes	Acid resistant brick (high H_2O absorption) Acid resistant brick (low H_2O absorption) Abrasion resistant brick (aluminum oxide)

(continued)

TABLE 15 (continued)

Generic	Specific	Trade or common name
		Abrasion/chemical resistant brick (oxide bonded silicon carbide)
		Refrax (silicon nitride-bonded silicon carbide)
	Hydraulically-bonded mortar	Kaocrete HS
		Pre-krete G-8
		Plibrico gunite
		Haydite/lumnite
	Hydraulically-bonded concrete	Portland cement
	Chemically-bonded mortar	Sauereisen No. 33
		Sauereisen No. 65
		Corlok B
		Pennwalt HES
	Chemically-bonded concrete	Sauereisen No. 54
		Sauereisen No. 72

part of an acidic slurry, corrosion-resistant alloys are required. The corrosion problems are accentuated when the chloride concentration in the FGD system becomes significant. In such instances carbon steel may be protected by an organic or ceramic material so that, it is presumed, the metal is not contacted with the scrubber liquids. There are various grades of carbon steel used. A-285, AISI 1110 and a high strength low alloy (HSLA) called Cor-Ten are most typical. Table 16 shows a breakdown of the composition of these materials.

Stainless Steel--

Wrought alloy stainless steels used in FGD systems are grouped as ferritic and austenitic. The ferritics are not widely used. The most common austenitic stainless steels are Type 316, 316L, 317, and 317L. These metals have increasing levels of nickel, chromium, and molybdenum with grade that greatly improve corrosion resistance to sulfuric acid concentrations that can accumulate in scrubbing systems (Table 16). These alloys have performed well in environments where chloride levels have not been excessively high and the pH has not dropped into the acid range for extended periods.

Cast alloy stainless steels used for FGD systems are only of the austinetic variety. Such materials have been used for pumps and valve construction. CD-4 MCU is a typical Austenitic castable stainless steel.

High Alloy--

High alloys are used in FGD systems for high chloride and/or low pH environments. High alloy metals used for FGD systems are either iron base or nickel base and are characterized by relatively high concentrations of chromium and/or molybdenum when compared to stainless steel. Such alloys commonly used are Carpenter 20, Alloy 904L, Incoloy 825, Hastelloy G, Hastelloy C-276, and Inconel 625. Table 16 shows a composition breakdown of these alloys.

Data indicate that the rate of corrosion attack is inversely proportional to the sum of the molybdenum and chromium content. Therefore, alloys such as Hastelloy C-276 and Inconel 625, which are more expensive than Type 316L stainless steel, are required for the optimum corrosion resistance in FGD systems with acidic conditions and high chloride concentrations. A large amount of Type 316L stainless steel has been used in FGD system components such as prescrubbers, absorbers, spray nozzles, reheaters, and dampers.

TABLE 16. NOMINAL CHEMICAL COMPOSITION OF BASE METALS (wt % except as indicated)

	Ni	Fe	Cr	Mo	Cu	C	Si	Mn	Al	S	P	Other elements
Carbon steel												
A-285		Balance			<0.35	<0.35		<0.8		<0.05	<0.05	
AISI 1010		Balance				0.1				<0.05	<0.04	
HSLA	0.44	Balance	0.92		0.41	0.08	0.46	0.31		0.033	0.11	
Stainless steel (wrought)												
430		Balance	16-18			0.12	1.00	1.00				
E-Brite 26-1		Balance	26.00	1.00		0.02	0.25	0.35		<0.03	<0.04	N, 0.03; Ti, 0.35
304	9.5	Balance	18.5			<0.08	<1.0	1.5				
304L	10.0	Balance	18.5			<0.03	<1.0	1.3				
316	13.0	Balance	17.0	2.25		<0.08	<1.0	1.7				
316L	13.0	Balance	17.0	2.25		<0.03	<1.0	1.8				
317	14.0	Balance	19.0	3.25		<0.08	<1.0	<2.0				
317L	14.0	Balance	19.0	3.25		<0.03	<1.0	<2.0				
Stainless steel (cast)												
CD-4 MCu	5.5	61.0	26.0	2.0	3.0	<0.04	<1.0	<1.0				
High-grade alloy (wrought)												
Carpenter 7	4.25	66.0	27.0	1.40	0.10	0.05	0.38	0.50		0.13	0.022	
Carpenter 20	34.0	39.0	20.0	2.50	3.30	<0.07	0.60	0.30				Combined Cb and Ta, 0.06
Uddeholm 904L	25.0	47.0	20.0	4.50	1.50	<0.02	0.35	1.70				
Climax 18-2	0.4	72.0	18.5	2.0	0.20	0.016	0.40	0.4				N, 0.013; Ti, 0.33
Incoloy 825	42.0	30.0	21.0	3.0	1.80	0.03	0.35	0.65	0.15			Ti, 0.90
Hastelloy G	45.0	20.0	22.0	6.5	2.00	0.03	0.35	1.30				W, 0.5; combined Cb and Ta, 2.12
Haynes 6B	2.0	2.0	29.75	1.0		<1.0	0.36	1.4				W, 4.3; Co, balance
Haynes 20	26.0	42.0	22.0	5.0		<0.05	<1.0	<2.5				Ti, minimum is four times carbon content
Jessup JS 700	25.0	46.0	21.0	4.5		0.03	0.5	1.7				Cb, 0.03
Allegheny AL-6X	24.0	46.0	20.0	6.5		<0.025	<0.5	<1.5				
Allegheny 29-4	0.1	66.0	29.0	4.0		0.004	0.01	0.10		0.013	0.013	N, 0.01
Nitronic 50	12.0	54.0	22.0	2.5		0.03	1.00	5.0				V, 0.20; N, 0.30; Cb, 0.20
Hastelloy C	54.0	5.0	15.5	16.0		<0.08	<1.0	<1.0				Co, <2.5; W, 4.0; V, <0.4
Hastelloy C-276	54.0	5.0	15.5	16.0		<0.02	<0.05	<1.0				Co, <2.5; W, 4.0; V, <0.4
Hastelloy C-4	Balance		15.7	14.8		0.008	0.04			<0.005	0.007	
Inconel 625	60.0	5.0	21.5	9.0		<0.1	<0.5	<0.5				Combined Cb and Ta, 3.65
High-grade alloy (cast)												
IN-862	24.0	44.0	21.0	5.0		<0.04	0.8	0.5				
Other metals												
Titanium		0.13				0.022						O_2, 0.12; Ti, balance
Zirconium 702		0.05	0.05			0.015						N, 0.05; Hf, <0.1; combined Zr and Hf, >99.2

Moderate use has been made of Inconel 625 in critical locations such as outlet ducts, outlet dampers, and reheaters. Hastelloy G, which has a lower molybdenum content than Inconel 625 or Hastelloy C-276, also has been utilized for vulnerable components. Carbon steel and high-strength, low-alloy steels such as Cor-Ten have been reserved for areas where alkaline conditions prevail, or are protected by a lining.

Other Metals--

Titanium and Zirconium 702 are metals being considered and/or used on a very limited basis for FGD system application. These metals have excellent corrosion resistance to sulfuric and hydrochloric acid environments, however, they are very expensive and difficult to handle in fabrication.

15.1.2 Plastics, Ceramics and Protective Linings - Construction Material Classification Descriptions

The utility industry uses two major types of protective linings: organic and inorganic. Organic linings include resins, rubber, and plastics. Inorganic linings include bricks, ceramics, and concrete.

Organic Linings--

Organic linings have been used extensively in various components of flue gas desulfurization systems including prescrubbers, absorbers, outlet ducts, stacks, and tanks. They are attractive because their use to protect carbon steel provides the lowest price materials choice for many of these components. Two types of sheet rubber have been used for lining absorbers: natural (gum) and neoprene. Natural rubber is better than neoprene in both abrasion and chemical resistance, but neoprene is less flammable.

Among the basic organic linings, the polyester, bituminous resins, epoxy, vinyl ester, and rubber linings are the most commonly used in utility FGD systems. Table 17 summarizes the resistance properties of these material in various environments. Programs of systematic testing with the various organic linings have indicated that the type of coating, the thickness of the coating, application techniques, and degree of surface preparation are important variables affecting performance.

TABLE 17. ORGANIC LININGS: BASE MATERIALS AND RESISTANCE TO SOME ENVIRONMENTS

Name	Base material	Resistance to environment						
		Abrasion	Heat	Acid	Alkali	Solvent	Water	Weather
Bituminous	Coal tar	F	P	F	F	P	F	F
Chlorinated rubber	Chlorine, natural rubber	F	P	G	G	P	E	F
Natural rubber		E	F	G	G	P	E	E
Fluorocarbons	Fluorine, ethylene	E	E	E	E	E	E	E
Epoxy	Epichlorohydrin, Bisphenol-A	G	G	G	E	G	G	G
Coal tar epoxy	Coal tar, epoxy	F	F	G	G	P	G	G
Polyesters	Phthalic acid, Bisphenol-A	G	G	E	F	G	G	G
Vinyls		F	P	E	G	P	E	E

E - Excellent - May be used under all conditions.
G - Good - May be used under all conditions.
F - Fair - May be used under certain conditions.
P - Poor - Should not be used under any conditions.

Table 15 shows specific types of these liners used in FGD systems and trade or common names for some of these.

Organic linings provide protection by acting as a physical barrier to exclude the corrosive environment from the underlying metal. To provide the necessary barrier properties, the lining must bond well to the metal surface and must not be displaced by the fluids to which it is exposed. Moreover, the lining must not be attacked by the chemicals in the environment nor be degraded by the temperatures to which it is exposed. This limits the choice of resins that can be used. Polyester, vinyl ester, epoxy, and fluoropolymer resins have been used in linings for various components of FGD systems. The maximum recommended service temperatures for resin-based linings are 180°F (wet) and 250°F (dry) for polyester and epoxy, 360°F (dry) for vinyl ester, and 400°F for fluoropolymer. Because of its high cost, the latter resin has been used only in linings for components that are exposed to relatively high temperatures, e.g., outlet ducts downstream from the bypass junction and stacks.

Mica, alumina, glass, and other flake types as well as fiber and mat materials are added to or used in conjunction with organic materials in organic liners to decrease the permeability of the liner, improve the structural characteristics, and improve the temperature range of the liner.

Some miscellaneous types of linings have also been used in FGD system components. For example, bitumastic, epoxy, and coal tar epoxy linings have been used to a limited extent in tanks and thickeners.

Inorganic Linings--

Inorganic materials are used in prescrubbers, spray nozzles, slurry pumps, outlet ducts, bypass ducts, and stacks of FGD systems. The materials include prefired bricks and shapes, hydraulically alloy-bonded concretes and mortars, and chemically-bonded concretes and mortars, all of which are used as linings where temperature resistance, chemical resistance, and/or abrasion resistance are required. Prefired shapes are also used for spray nozzles and pump components. The bricks used most often in FGD systems are red shale, fire clay, and silicon carbide. Red shale can be used where minimum permeation of liquor through the brick is required and thermal shock is not a factor. Fire clay can be used where minimum absorption is not required and thermal shock is a factor. Silicon carbide brick is used where high resistance to abrasion is required. To minimize corrosion problems resulting from permeation through these linings it is common practice today to apply an organic liner to the carbon shells which support these materials at least in the case of brick liners. Permeation problems may also be minimized by slightly pressurizing the space between the brick and the carbon steel shell (e.g., pressurized stack annulus).

Selection of ceramics is governed by their physical properties, which result in objects of relatively thick cross-section, heavy weight, and lack of resistance to impact. Since ceramic shapes are usually made by extrusion or casting, the shapes that are symmetrical (nozzles, cylindrical scrubbers, ductwork, piping) are most suitable. Where ceramics are used, it is nearly impossible to make changes, adaptations, or repairs in the field that will provide resistance equivalent to that of the as-fired material.

Unlike the ceramics, concrete need not be fired as a formed shape to achieve strength and resistance but achieves these values by the process of hydration. To meet strength requirements, concrete is usually reinforced with steel; more recently, fibrous materials have been used for reinforcement. Concrete is often used in presaturators, tanks, and piping. In strong sulfuric acid solutions (pH below 4) the calcium aluminate cements are attacked by a solution mechanism. Calcium aluminate cements are, however, resistant to hydration reactions which cause cracking. They are commonly used in mortar for constructing stack linings and in refractory castable mixes used as erosion resistant linings in venturi prescrubbers and quench ducts. However, if condensation occurs, and the pH of the attacking solution becomes low enough, failures by bond solution might be expected, resulting in the loosening of the aggregate and erosive wear of the lining.

Chemically-bonded mortars are commonly used to bond acid resistant brick stack linings. Chemically-bonded concrete mixes (commonly applied by gunite technique although they can also be cast or troweled) can be used as linings. They generally contain siliceous aggregates, a sodium silicate, potassium silicate, or colloidal silica bond phase, and a silicofluoride, phosphate, or organic bond gelling agent (like chemically-bonded mortars). However, they are formulated to set much faster than mortars, and may have additives which may help them stick to vertical walls without slumping.

The reaction products of these cements are high silica phases which are not easily dissolved by acidic solutions. However, sodium silicate undergoes a sulfidation reaction with sulfuric acid which can crack the cement. A similar reaction occurs with potassium silicate, but an amorphous reaction product is formed which does not produce a detrimental expansion force. To avoid these problems, commercial materials either modify sodium silicate bonds to make them resistant to hydration, or utilize potassium silicate or colloidal silica bonds. Since chemically-bonded concretes can withstand hot acidic environments, they offer an abrasion-resistant alternative to organic linings. However, they have a finite permeability (and may crack), so any condensed acid may ultimately reach the substrate to which they are applied.

Inorganic linings often appear in areas where high temperatures and abrasion is a problem and/or where saturation occurs. Presaturators are prime candidates for inorganic liners because of the critical gas temperature environment. In presaturators the flue gas may enter at 300°F and drop to 130°F as saturation takes place.

Table 15 shows a breakdown of specific inorganic materials used in FGD systems and some trade or common names for these types.

SECTION 16

BASIC FAN CLASSIFICATIONS

A fan is a piece of equipment used to move gas by creating a high or low pressure through mechanical means. Fans are used in utility boiler installations to force combustion air into and/or draw flue gas from the boiler furnace as well as through the FGD system.

16.1 CLASSIFICATIONS

Fans used in FGD systems fall into four basic classifications in FGDIS: function, design, application, and service (Table 18). These are described in the text that follows:

16.1.1 Function

A fan used for an FGD system may be designed to function as either a unit or booster fan. A unit fan is one that is designed to create draft for both the boiler and FGD system. A booster fan is designed to accommodate all or part of the FGD system but does not supply draft for the boiler.

Retrofit FGD systems usually include booster fans since existing boiler fans would generally be unable to accommodate the pressure drop of the add-on FGD system. Booster fans are also often used for FGD systems that have a scrubber bypass capability. Booster fans may be used for individual modules on FGD systems to give better control of the gas passing through them.

Unit fans are generally used for new FGD-equipped boilers, particularly installations where flue gas bypass does not exist. Using unit fans allows better balance of the draft throughout the entire unit and generally requires less initial capital cost.

TABLE 18. BASIC FAN CLASSIFICATIONS

Function	Design	Application	Service
Unit/booster	Centrifugal/axial	ID/FD (induced draft/forced draft)	Wet/dry

Design

Fans used for FGD systems are of either the centrifugal or axial variety (Figure 39). A centrifugal fan consists of a cylinder of slat- type vanes (or blades) aligned parallel to the entering gas stream. The cylinder rotates rapidly about an axis also parallel to the entering gas stream casting the gas outward into the housing and through an exiting duct connected tangentially to the housing.

Axial flow fans consist of propeller-like vanes (or blades) that rotate in a plane perpendicular to the gas stream about a shaft resting in a plane parallel to the gas stream.

Most fans used in FGD systems are of the centrifugal variety. Both fan designs may be equipped with variable-pitch vanes (or blades which provide more efficient fan operation and better gas flow control).

Application

Fans used in FGD systems may be classified as ID (induced draft) or FD (forced draft). Fans that are installed downstream of a module or system that draw gas through the module or system are called ID fans. Fans that precede a module or system that push gas through the system are called FD fans.

Service

Fans may service either a wet or dry gas stream. Fans that precede scrubbers operate on hot dry flue gas are classified as dry fans. Fans that are installed downstream from scrubbers but are preceded by a flue gas reheater are also classified as dry fans. Fans that are installed either between scrubber (scrubber/absorber) modules or downstream from scrubbers but are not preceded by a flue gas reheater are classified as wet fans.

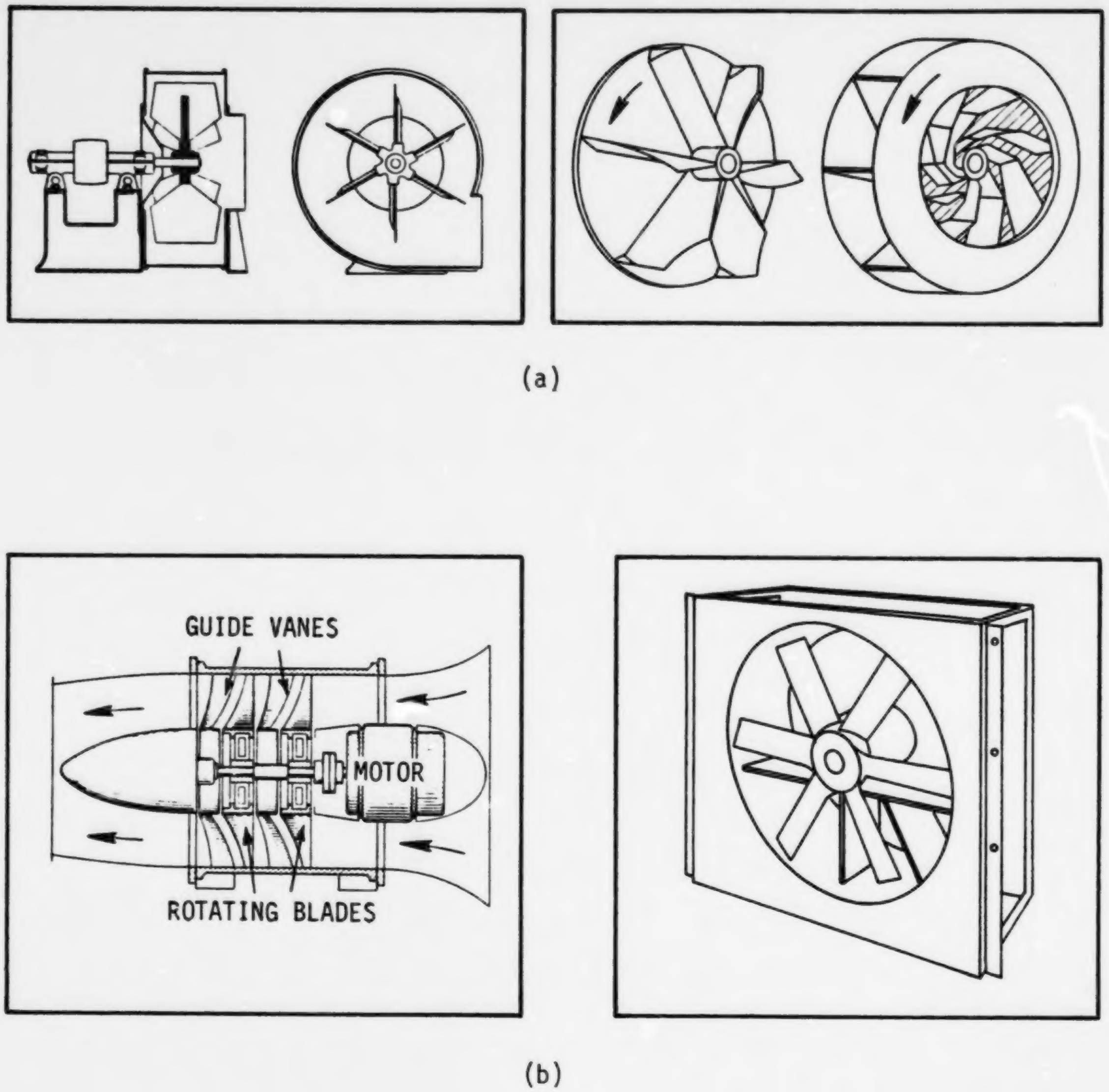

(a)
GUIDE VANES
MOTOR
ROTATING BLADES
(b)

Figure 39. Fan designs included in FGDIS:
(a) centrifugal; (b) axial.

APPENDIX A

REPORT WRITER PROGRAMS

The following documentation represents Report Writer programs that are available for use in conjunction with the FGDIS. A sample runstream is provided as a guide to the use of each program; however, Section 3.4 provides additional discussion. Also provided is a program abstract, sample output and suggested uses/comments. If assistance with a program is required, the person listed at the top of each sheet can be contacted. As new programs become available, this appendix will be updated.

DATA BASE PROGRAM DOCUMENTATION

1. PROGRAM NAME

TOTPRO

2. FILE NAME

FGDIS

3. DATA BASE NAME

FGDIS

4. LANGUAGE

REPORT WRITER

5. DATE WRITTEN

8/79

6. NAME/PHONE FOR ASSISTANCE

M. Melia, B. Pelsor (PEDCo) 513-782-4700

7. PROGRAM ABSTRACT

The purpose of the TOTPRO program is to generate a table which provides a breakdown of the various FGD processes with respect to system status. The processes are further broken down into the categories of saleable end product and throwaway end product with a final figure showing the percent of the total number of systems that produce a saleable end product.

8. SAMPLE RUNSTREAM

The following commands are used within System 2000:

```
---
>@ADD FGDIS.TOTPRO
---
---
>GENERATE TOTPRO:
```

9. SAMPLE OUTPUT

See attached (this output was generated with the above commands).

10. SUGGESTED USES/COMMENTS

Note that any valid WHERE clause can be used in conjunction with the GENERATE statement to limit the data sets selected. For example, it would be possible to generate a process versus status listing for high sulfur coal FGD applications with the command:

```
GENERATE TOTPRO WHERE CO HAS C213 GT 2.5:
```

The table generated would then show only those processes that were either in use or planned for use at stations using coal with an average sulfur content of greater than 2.5 percent.

SUMMARY OF DOMESTIC FGD SYSTEMS BY PROCESS

	TOTAL		OPERATIONAL		CONSTRUCTION		CONTRACT AWARDED		PLANNED	
	NO.	MW	NO.	MW	NO.	MW	NO.	MW	NO.	MW
AQUEOUS CARBONATE/SPRAY DRYING	1	100	1	100	0	00	0	00	0	00
CITRATE	1	60	1	60	0	00	0	00	0	00
LIME	1	65	0	00	1	65	0	00	0	00
LIMESTONE	1	166	0	00	1	166	0	00	0	00
LIME/LIMESTONE	1	475	0	00	1	475	0	00	0	00
MAGNESIUM OXIDE	3	724	1	240	2	484	0	00	0	00
WELLMAN LORD	7	1959	7	1959	0	00	0	00	0	00
SUBTOTAL-SALEABLE PRODUCT	15	3549	10	2359	5	1190	0	00	0	00
DUAL ALKALI	6	2288	3	1181	2	842	1	265	0	00
LIME	32	14145	24	9680	5	2805	1	650	2	1010
LIMESTONE	82	39382	38	13920	19	9362	14	10060	11	6040
LIMESTONE/ALKALINE FLYASH	2	1500	2	1500	0	00	0	00	0	00
LIME/ALKALINE FLYASH	11	4238	9	2838	2	1400	0	00	0	00
LIME/LIMESTONE	2	20	2	20	0	00	0	00	0	00
LIME/SODIUM CARBONATE	1	100	1	100	0	00	0	00	0	00
LIME/SPRAY DRYING	13	4263	1	110	9	2893	3	1260	0	00
PROCESS NOT SELECTED	6	3530	0	00	0	00	0	00	6	3530
SODIUM CARBONATE	9	3155	5	1255	1	250	0	00	3	1650
SODIUM CARBONATE/SPRAY DRYING	1	440	1	440	0	00	0	00	0	00
SUBTOTAL-THROWAWAY PRODUCT	165	73061	86	31044	38	17552	19	12235	22	12230
TOTAL	180	76610	96	33403	43	18742	19	12235	22	12230
SALEABLE % OF TOTAL MW		5		7		6		0		0

42 (26618 MW) UNITS LISTED AS "UNDECIDED" WERE NOT INCLUDED IN THESE TABULATIONS
THESE MEGAWATT RATINGS ARE EQUIVALENT SCRUBBED.

DATA BASE PROGRAM DOCUMENTATION

1. PROGRAM NAME TOTMW	**2. FILE NAME** FGDIS
3. DATA BASE NAME FGDIS	**4. LANGUAGE** REPORT WRITER
5. DATE WRITTEN 8/79	**6. NAME/PHONE FOR ASSISTANCE** M. Melia, B. Pelsor (PEDCo) 513-782-4700

7. PROGRAM ABSTRACT The purpose of the TOTMW program is to generate a table which provides a breakdown of the various FGD systems in the data base with respect to status. Included for each status is a total number of systems and a total MW value, in terms of both Total Controlled Capacity and Equivalent Scrubbed Capacity.

8. SAMPLE RUNSTREAM The following commands are used within System 2000:

```
---
>@ADD FGDIS.TOTMW
---
---
>GENERATE TOTMW:
```

9. SAMPLE OUTPUT See attached (this output was generated using the above commands).

10. SUGGESTED USES/COMMENTS A valid WHERE clause can be used in conjunction with the GENERATE statement to limit the units included in the table, although one is not necessary if a complete table inclusive of all units is desired. As an example, if a table illustrating the status of units utilizing limestone as the reagent was desired the command would be:

```
GENERATE TOTMW WHERE C803 EQ LIMESTONE:
```

NUMBER AND TOTAL MW OF FGD SYSTEMS AND PARTICLE SCRUBBERS
03/07/84

STATUS	UNITS	TCC-MW	ESC-MW
OPERATIONAL	120	48561	44946
UNDER CONSTRUCTION	23	13707	13602
PLANNING			
CONTRACT AWARDED	20	12189	11915
LETTER OF INTENT	7	6060	6060
REQUESTING-EVALUATING BIDS	2	1150	1150
CONSIDERING ONLY	41	23878	23700
SUBTOTAL	213	105545	101373
PARTICLE SCRUBBERS	14	2728	2579
SUBTOTAL-DOMESTIC	227	108273	103952
JAPANESE FGD	7	1805	1805
TOTAL	234	110078	105757

DATA BASE PROGRAM DOCUMENTATION

1. PROGRAM NAME COLIST

2. FILE NAME FGIDS

3. DATA BASE NAME FGDIS

4. LANGUAGE REPORT WRITER

5. DATE WRITTEN 8/79

6. NAME/PHONE FOR ASSISTANCE M. Melia, B. Pelsor (PEDCo) 513-782-4700

7. PROGRAM ABSTRACT The purpose of the COLIST program is to generate a table displaying company name, unit name and number, unit location, initial start-up date, status, and regulatory class. These are listed alphabetically by company and unit.

8. SAMPLE RUNSTREAM The following commands are used within System 2000:

```
---
>@ADD FGDIS.COLIST
---
---
>GENERATE COLIST:
```

9. SAMPLE OUTPUT The following output was generated by the above commands:

```
                      DATE:09/29/82
COMPANY                                                                START          REG.
    UNIT NAME                   NO.          UNIT LOCATION             DATE   STATUS  CLASS
-------------------------------------------------------------------------------------------
ALABAMA ELECTRIC
    TOMBIGBEE                   2       LEROY          ALABAMA         7809     1      B
    TOMBIGBEE                   3       LEROY          ALABAMA         7906     1      B

ARIZONA ELECTRIC POWER
    APACHE                      2       COCHISE        ARIZONA         7808     1      D
    APACHE                      3       COCHISE        ARIZONA         7906     1      D

ARIZONA PUBLIC SERVICE
    CHOLLA                      1       JOSEPH CITY    ARIZONA         7310     1      D
    CHOLLA                      2       JOSEPH CITY    ARIZONA         7804     1      D
```

10. SUGGESTED USES/COMMENTS Note that any valid WHERE clause can be used in conjunction with the GENERATE clause to specify the units that will be included in the list. For example, an alphabetical listing of high sulfur coal FGD applications could be obtained using the following:

```
GENERATE COLIST WHERE CO HAS C213 GT 2.5:
```

As a second example, an alphabetical listing of all operational systems could be obtained with the following:

```
GENERATE COLIST WHERE C812 EQ 1:
```

PEDCo ENVIRONMENTAL, INC. 1979

DATA BASE PROGRAM DOCUMENTATION

1. PROGRAM NAME PERAVG

2. FILE NAME FGDIS

3. DATA BASE NAME FGDIS

4. LANGUAGE REPORT WRITER

5. DATE WRITTEN 8/78

6. NAME/PHONE FOR ASSISTANCE M. Melia, B. Pelsor (PEDCo) 513-782-4700

7. PROGRAM ABSTRACT The PERAVG program was designed to provide the user with a performance history of any unit(s) in question. It generates a table that displays four dependability parameters (availability, reliability, operability, utilization) as well as capacity factor, boiler hours, FGD system operating hours, and period hours for the time period and unit(s) specified. Also included is the average value of each of the dependability parameters for the specified time period.

8. SAMPLE RUNSTREAM The following commands are used within System 2000:

```
---
>@ADD FGDIS.PERAVG
---
---
>GENERATE PERAVG WHERE C1 EQ 46 AND C3401 GT 8200:
 -479- LOWEST SELECTED RECORD COMMON TO ALL REPORTS IS 3440 -
```

9. SAMPLE OUTPUT The following output was generated by the above commands:

```
                    KANSAS CITY POWER & LIGHT                 NET GENERATING CAPACITY WITH FGD = 820
                    LA CYGNE                                  GROSS GENERATING CAPACITY = 874
                    1                                         % SCRUBBED = 100

              CAPACITY   PERIOD   BOILER    FGD
      DATE     FACTOR    HOURS    HOURS    HOURS    AVAILABILITY    OPERABILITY    RELIABILITY    UTILIZATION
      ----    --------   ------   ------   -----    ------------    -----------    -----------    -----------
      8201      33.4      744      511      483         92.5            91.3           89.7            64.9
      8202      24.0      672      348      367         96.4            90.6           93.5            58.3
      8203      33.3      744      441      449         95.8            93.8           93.2            60.4
      8204      20.5      720      282      278         98.9            94.7           97.3            38.6
      8205       0.0      744       00        0        100.0            ***            ***              0.0
      8206      13.0      720      197      206         97.5            93.9           91.7            28.7
                ----                                    -----           -----          -----           -----
  AVERAGE       20.7                                    96.8            92.9           93.1            41.8


  NOTE:  *'S INDICATE THAT THE VALUE DOES NOT EXIST.
```

10. SUGGESTED USES/COMMENTS It should be noted that a WHERE clause must be used in conjunction with the GENERATE statement which specifies the unit(s) and time period desired, Otherwise the program will utilize all performance data available, resulting in large amounts of output. As an example, if the performance history of low sulfur coal FGD applications was desired for the year 1978, the command would be:

```
GENERATE PERAVG WHERE CO HAS C213 LT 2.5 and C3401 EQ 7800*7812:
```

DATA BASE PROGRAM DOCUMENTATION

1. PROGRAM NAME ABSTCT

2. FILE NAME FGDIS

3. DATA BASE NAME FGDIS

4. LANGUAGE REPORT WRITER

5. DATE WRITTEN 8/79

6. NAME/PHONE FOR ASSISTANCE M. Melia, B. Pelsor (PEDCo) 513-782-4700

7. PROGRAM ABSTRACT The ABSTCT program is designed to provide the user with a short paragraph presenting a general overview of the unit(s) specified. Included in the paragraph are data such as unit MW ratings, unit location, boiler and FGD system type, FGD process utilized, etc.

8. SAMPLE RUNSTREAM The following commands are used within System 2000:

```
---
>@ADD FGDIS.ABSTCT
---
---
>GENERATE ABSTCT WHERE C1 EQ 157:
 -479- LOWEST SELECTED RECORD COMMON TO ALL REPORTS IS 4000 -
```

9. SAMPLE OUTPUT The following output was generated with the above commands:

```
   BIG RIVERS ELECTRIC                    MW-GROSS; 242
   GREEN                                  MW-NET WITH FGD; 222
   2                                      MW-ESC; 242

 UNIT 2 OF BIG RIVERS ELECTRIC'S GREEN STATION IS LOCATED IN SEBREE,
 KENTUCKY. THE DRY BOTTOM PULVERIZED COAL (3.75% S, 9750 BTU/LB)
 FIRED BOILER SUPPLIES 1,000,000 ACFM TO A COLD SIDE ESP FOLLOWED BY
 TWO AMERICAN AIR FILTER LIME SPRAY TOWERS WHICH REMOVE 90% OF THE
 SO2. THE CLEANED GAS PASSES THROUGH A CHEVRON MIST ELIMINATOR AND
 EXITS A SAUERISEN 72 LINED STACK AFTER IT IS HEATED BY A STEAM COIL
 REHEATER. THE SLUDGE FROM THE CLOSED WATER LOOP SYSTEM IS POZ-O-TEC
 STABILIZED. OPERATIONS COMMENCED IN NOVEMBER 1980.
---
>
```

10. SUGGESTED USES/COMMENTS This program is helpful when a general description of FGD operations at a unit is desired in paragraph form. Any valid WHERE clause can be used in conjunction with the GENERATE statement to limit the number or type of systems that will appear in the output. For example, a brief description in paragraph form could be provided for all retrofit systems by using the following command:

```
GENERATE ABSTCT WHERE CO HAS C809 EQ RETROFIT:
```

DATA BASE PROGRAM DOCUMENTATION

1. PROGRAM NAME IDS

2. FILE NAME FGDIS

3. DATA BASE NAME FGDIS

4. LANGUAGE Report Writer

5. DATE WRITTEN - 11/79

6. NAME/PHONE FOR ASSISTANCE M. Melia, B. Pelsor (PEDCo) 513-782-4700

7. PROGRAM ABSTRACT The IDS program was designed to generate a list displaying the identification numbers for each of the units in the FGD INFORMATION SYSTEM. Included is company name, unit name, unit number, and identification number. These are listed alphabetically by company name and unit.

8. SAMPLE RUNSTREAM The following commands are within System 2000:

```
>@ADD FGDIS.IDS
---
---
>GENERATE IDS:
```

9. SAMPLE OUTPUT The following output was generated by the above commands:

```
                DATE:09/29/82

  ID        COMPANY NAME                          UNIT NAME             UNIT NUMBER
------------------------------------------------------------------------------------------------
   1   ALABAMA ELECTRIC                        TOMBIGBEE                   2
   2   ALABAMA ELECTRIC                        TOMBIGBEE                   3
   5   ARIZONA ELECTRIC POWER                  APACHE                      2
   6   ARIZONA ELECTRIC POWER                  APACHE                      3
   7   ARIZONA PUBLIC SERVICE                  CHOLLA                      1
   8   ARIZONA PUBLIC SERVICE                  CHOLLA                      2
 152   ARIZONA PUBLIC SERVICE                  CHOLLA                      4
 112   ARIZONA PUBLIC SERVICE                  FOUR CORNERS                1
 113   ARIZONA PUBLIC SERVICE                  FOUR CORNERS                2
 114   ARIZONA PUBLIC SERVICE                  FOUR CORNERS                3
   9   ARIZONA PUBLIC SERVICE                  FOUR CORNERS                4
  11   ARIZONA PUBLIC SERVICE                  FOUR CORNERS                5
```

10. SUGGESTED USES/COMMENTS Note that a valid WHERE clause can be used to single out specific units.
Example:

```
GENERATE IDS WHERE C812 EQ 1:
```

This command would print only the operational systems.

DATA BASE PROGRAM DOCUMENTATION

1. PROGRAM NAME FNOTES

2. FILE NAME FGDIS

DATA BASE NAME FGDIS

4. LANGUAGE REPORT WRITER

5. DATE WRITTEN 2/80

6. NAME/PHONE FOR ASSISTANCE M. Melia, B. Pelsor (PEDCo) 513-782-4700

7. PROGRAM ABSTRACT

The FNOTES program was designed to provide the user with a listing of the footnotes contained in the data base for the unit(s) and element(s) in question. Along with the footnotes, the output provides the element number to which the footnote pertains.

8. SAMPLE RUNSTREAM The following commands are used within System 2000:

```
---
>@ADD FGDIS.FNOTES
---
---
>GENERATE FNOTES WHERE C1 EQ 19:
 -479- LOWEST SELECTED RECORD COMMON TO ALL REPORTS IS 4000 -
```

9. SAMPLE OUTPUT The following output was generated with the above commands:

```
     CENTRAL ILLINOIS LIGHT                      MW-GROSS;  416
     DUCK CREEK                                  MW-NET WITH FGD;  378
     1                                           MW-ESC;  416

  FOOTNOTE     ELEMENT
  NUMBER       NUMBER                                   FOOTNOTE
  --------     -------                                  --------

     1           810     NOT USED FOR PARTICULATE REMOVAL.

     2           815     ONE MODULE SYSTEM - THE REMAINING 75% INSTALLED IN AUGUST, 1976

     3          1110     RODS ARE MADE OF 316L SS

     4          1117     POLYSPHERE BALLS
```

10. SUGGESTED USES/COMMENTS

This program enables the user to access any footnotes that might exist for a specified unit or field. A valid WHERE clause can be used in conjunction with the GENERATE statement to limit the selected units and fields if desired. As an example, if the footnotes for the ABSORBER TYPE field for units utilizing a limestone process were desired the command would be:

```
GENERATE FNOTES WHERE CO HAS C803 EQ LIMESTONE AND C4005 EQ 1105:
```

DATA BASE PROGRAM DOCUMENTATION

1. PROGRAM NAME
ECON

2. FILE NAME
FGDIS

3. DATA BASE NAME
FGDIS

4. LANGUAGE
REPORT WRITER

5. DATE WRITTEN

6. NAME/PHONE FOR ASSISTANCE
M. Melia, B. Pelsor (PEDCo) 513-782-4700

7. PROGRAM ABSTRACT The ECON program was designed to provide the user with economic data for any unit(s) in question. The table generated from this program displays reported capital and annual costs as well as adjusted costs.

8. SAMPLE RUNSTREAM The following commands are used within System 2000:

```
>@ADD FGDIS.ECON
---
---
>GENERATE ECON:
```

9. SAMPLE OUTPUT See attached (this output was generated by the above commands).

10. SUGGESTED USES/COMMENTS Note that a valid WHERE clause can be used to generate economics data for a single unit. For example:

```
GENERATE ECON WHERE C1 EQ 1:
```

```
ALABAMA ELECTRIC                        MW-GROSS;  255
TOMBIGBEE                               MW-NET WITH FGD;  235
2                                       MW-ESC;  179


                          REPORTED
                          --------

*CAPITAL  1978                               *ANNUAL   1978
   DIRECT -     $5,826,750                       DIRECT -    $434,929
   INDIRECT -     $1,165.350                     OVERHEAD -
   OTHER CHARGES -                               FIXED CHARGES -
   TOTAL =     $6,992,100                        TOTAL =     $434,929
   TOTAL $/KW =    27.4                          TOTAL MILLS/KWH =  0.33

                          ADJUSTED
                          --------

*CAPITAL  1981                               *ANNUAL   1981
   DIRECT -                                      DIRECT -  $2,226,150
   INDIRECT -                                    OVERHEAD -    $332,750
   OTHER CHARGES -                               FIXED CHARGES -  $1,690,750
   TOTAL =     $9,756,200                        TOTAL =     $4,249,650
   TOTAL $/KW =    38.3                          TOTAL MILLS/KWH =  3.18
```

DATA BASE PROGRAM DOCUMENTATION

1. PROGRAM NAME PEDATA

2. FILE NAME FGDIS

3. DATA BASE NAME FGDIS

4. LANGUAGE Report Writer

5. DATE WRITTEN

6. NAME/PHONE FOR ASSISTANCE M. Melia, B. Pelsor (PEDCo) 513-782-4700

7. PROGRAM ABSTRACT The PEDATA program was designed to provide the user with brief descriptions of FGD-related problems, problem solutions, and/or comments for a specified time period. The statements are listed chronologically and each relates to a specific area of the FGD system.

8. SAMPLE RUNSTREAM The following commands are used within System 2000:

```
>@ADD FGDIS.PEDATA
---
---
>GENERATE PEDATA WHERE C1 EQ 1:
 -479- LOWEST SELECTED RECORD COMMON TO ALL REPORTS IS 3470 -
```

9. SAMPLE OUTPUT The following output was generated with the above commands:

```
               ALABAMA ELECTRIC
               TOMBIGBEE
               2



                      ***7809***
INITIAL OPERATION OF THE FGD SYSTEM BEGAN ON SEPTEMBER 23.  THE SCRUBBER
MODULES WERE FORCED OUT OF SERVICE 34 HOURS WHEN, AFTER CLOSING THE
SYSTEM ISOLATION DAMPERS THE UTILITY WAS UNABLE TO OPEN THEM AGAIN.


                      ***7810***
IN LATE OCTOBER AND EARLY NOVEMBER A FIBERGLASS ELBOW IN THE WASTE SLURRY
PIPE RUPTURED AND HAD TO BE REPLACED.
```

10. SUGGESTED USES/COMMENTS This program enables the user to access any problem/solution description for a specified unit, time period, or problem type. A valid WHERE clause can be used in conjunction with the GENERATE statement to limit the selected units and problem/solutions if desired. For example, a listing of all problem/solutions during 1981 relating to dampers for operational units could be acquired with the following command:

```
GENERATE PEDATA WHERE C0 HAS C812 EQ 1 AND C3461 EQ 8101*8112 AND C3463 EQ GD:
```

DATA BASE PROGRAM DOCUMENTATION

1. PROGRAM NAME

REMOVE

2. FILE NAME

FGDIS

3. DATA BASE NAME

FGDIS

4. LANGUAGE

Report Writer

5. DATE WRITTEN

10/83

6. NAME/PHONE FOR ASSISTANCE

M. Melia, B. Pelsor (PEDCo) 513-782-4700

7. PROGRAM ABSTRACT

The REMOVE program was designed to provide the user with removal performance data for any unit in question. It generates a table that displays actual SO_2, particulate, and NO_x removal efficiencies for a particular module and/or system during a specified time period. The table also includes opacity readings and gives detailed information on SO_2 analyses.

8. SAMPLE RUNSTREAM

```
---
>@ADD FGDIS.REMOVE
---
---
>GENERATE REMOVE WHERE C1 EQ 57:
 -479- LOWEST SELECTED RECORD COMMON TO ALL REPORTS IS 3900 -
```

9. SAMPLE OUTPUT

```
LOUISVILLE GAS & ELECTRIC                    MW-GROSS= 358
MILL CREEK                                   MW-NET WITH FGD= 334
1                                            MW-ESC= 358

-------------------------------------------------------------------------------------------
   .                 SO2          SO2                SO2      SO2    PARTICULATE          NOX
  DATE             ANALYSIS     ANALYSIS            OUTLET   REMOVAL   REMOVAL   OPACITY REMOVAL
(YYMMDD) MODULE    DURATION      METHOD            LB/MMBTU    %         %         %       %
-------------------------------------------------------------------------------------------
 801200  SYSTEM                                              90.0
 810100  SYSTEM               EPA-6                          94.8
 811000  SYSTEM   30 DAYS     IN-LINE MONITOR                95.0      99.5      25.0
 811100  SYSTEM   30 DAYS     IN-LINE MONITOR                95.0      99.5      25.0
 811200  SYSTEM   30 DAYS     IN-LINE MONITOR                95.0      99.5      25.0
 820400  SYSTEM   3 MONTHS    EPA-6                          95.0      99.0      15.0
 820700  SYSTEM   30 DAYS     EPA-6                          95.0      99.0      25.0
 820800  SYSTEM   30 DAYS     EPA-6                          95.0      99.0      25.0
 820900  SYSTEM   30 DAYS     EPA-6                          95.0      99.0      25.0
 830900  SYSTEM   3 MONTHS    EPA-6                          95.0      99.0      15.0
                                                   -------   -----     -----     -----   -----
AVERAGE                                                      94.5      99.2      22.5
```

10. SUGGESTED USES/COMMENTS

A valid WHERE clause can be used in conjunction with the GENERATE statement to limit the removal performance data to selected data fields. For example:

```
GENERATE REMOVE WHERE cl EQ 57 AND C3901 EQ 810000*820000:
```

This command would generate removal performance data reported during 1981 for the unit in question.

APPENDIX B

FILE CREATION/FILE MANIPULATION

Within the Univac 1100 Series Executive, there is the Text Editor (ED processor) which permits the user to manipulate the text of a symbolic file or element. This appendix contains the information for creating a file and then manipulating the file to obtain the proper output.

The following procedure is used to assign files for use within System 2000.

1. While in the data base, type the following:

   ```
   EXIT:
   ```

   which will terminate use of the data base but continue the session on the Univac.

2. The normal response to the above command will be:

   ```
   DATE---TIME---END SYSTEM 2000
   Release 2.90A
   ```

3. After receipt of the computer prompter (>), type:

   ```
   @ASG,CPΔ[filename].
   ```

   The [filename] is simply seven or less letters assigned to the file for further reference. The normal response to this will be:

   ```
   READY
   ```

4. After receipt of the computer prompter (>), type:

   ```
   @FREEΔ[filename].
   ```

   The [filename] must correspond to those used in Step 3. This statement catalogues the file at this time. If the file is not "freed" and the run is terminated abnormally, then the file will not be catalogued. The normal response to this will be:

   ```
   READY
   ```

5. After receipt of the computer prompter (>), type:

   ```
   @ED,IΔ[filename].
   ```

The [filename] must correspond with those used in Steps 3 and 4. This command directs the editor to enter input mode. In this mode, everything which is typed is inserted in the file until an exit from the mode is taken. This is especially useful when large volumes of input are to be entered. The normal response to this will be:

```
     Case Upper Assumed
     ED 16R1-DAY-DATE-TIME
     INPUT
  1I:>
```

6. After receipt of the line number 1, the user can enter any statements to create the print needed. After the addition of the print clauses, the user exits the file by first pressing the carriage return. This places the user in the edit mode and the computer response is the following:

```
     EDIT
  56:>             (or the last line of the file)
```

The user now types EXIT, which will cause the file to be catalogued and terminates the use of the file. The normal response to this will be:

```
     Lines:  56 FIELDATA
```

Note: This tells the total number of lines created in the file.

7. To run the file, issue the following command:

```
     @ADD△[filename].
```

This command should be issued while in the data base.

The following procedure is used to correct any errors that may occur while inserting the lines within the file or to modify the file for further use:

8. While in the data base, type the following:

```
     EXIT:
```

which will terminate use of the data base but continue the session on the Univac.

9. The normal response to the above command will be:

```
DATE---TIME---END SYSTEM 2000
Release 2.90A
```

10. After receipt of the computer prompter (>), type:

```
@ED,UΔ[filename].
```

The [filename] must correspond to the file created in Step 3. This command initiates the editor and allows any corrections, additions, or deletions to be made. The normal response to this command will be:

```
  Case Upper Assumed
  ED 16RI-DAY-DATE-TIME
  EDIT
0:>
```

11. The following are ED processor commands:

IN - This command allows inline editing of a given line. If "number" is blank, the current line is assumed to be the one to be edited, unless the command is followed by a +, in which case the next line will be the one to be edited. The line will be printed out. The user can then enter editing information directly below the line to modify it. The termination character for editing commands is the exclamation point ("!"). The editing characters to be used are:

I - The string following this command is inserted following the character immediately above the I. The string is delimited on the right by the termination character !.

R - The characters following the R will replace the characters immediately above them. A ! is required to terminate replacement.

D - The characters in the line above are deleted between D and the !.

CΔ/string-1/string-2/mΔG - This command searches a specified number of text lines starting with the current line and ending with the specified line. When and if the desired string, "string 1", is found, "string 2" is substituted for it. The number of lines to be scanned is indicated by "m". The global indicator, "G", tells whether to change all occurrences of "string 1" in the range of lines or just the first occurrence in each line. A "G" means all occurrences and no character means just the first. The "/" may be any character which does not occur in "string 1" or "string 2" except a blank. The "m" may be omitted in which case 1 is assumed instead of using "m" and "G". A user may change all subsequent occurrences in the file by using the word "ALL" (which may be abbreviated A) where "m" is usually specified. Instead of using a large value for m, the user may specify the word REP (which may be abbreviated R) to indicate that the first occurrence on each line of the rest of the file is to be changed.

DΔnum 1 Δnum 2 - This command is used to delete lines from the text. This form deletes lines "num 1" through "num 2".

Input - This command directs the editor to enter input mode. In this mode, everything which is typed is inserted in the file until an exit from the mode is taken. This is especially useful when large volumes of input are to be entered. Exiting from this mode is accomplished by pressing the carriage return, which will put the user in edit mode, and typing EXIT.

LAST - This command directs the editor to move to the last line in the file and stay in edit mode.

TOP - This command directs the editor to move to the first line in the file and stay in edit mode.

LΔstring - This command is used to search the text for a given string of characters. The search begins at the line following the current line and proceeds sequentially through the text until a find is made or the end of file is encountered.

PΔnum 1 Δnum 2 - This command is used to print out lines of text. The first form prints lines "num 1" through "num 2". The second form prints the next "num 1" lines. If the command is immediately followed with a +, the printing starts with the next line instead of the current one (example PRINT+3).

+num -num - This command is used to locate and print lines in the text. The first command indicates to go forward the specified number of lines and the second command indicates a move backward.

APPENDIX C

TYMNET DIAGNOSTIC MESSAGES

ALL PORTS BUSY or HOST OUT OF PORTS

No connection can be made with the host computer at this time because all host ports available to TYMNET are busy. Hang up and log in again in a few minutes.

CIRCUITS BUSY

All available paths to the TYMCOM are busy; hang up and log in in a few minutes.

DROPPED BY HOST SYSTEM

You have logged off and/or have been disconnected by the host computer. If the session is finished, hang up; if not, log in again.

HOST DOWN

The network is fully operational, but the host computer is down. Hang up and log in again in a few minutes.

HOST NOT AVAILABLE THRU NET

This message can appear if: 1) the TYMCOM, its neighbor(s), or a line between them is down, or 2) an invalid host has been requested, or 3) a new Supervisor is taking over the network and has not yet picked up the host. For 1) and 3), hang up and log in in about 10 minutes. A 2) error may be the result of a mistyping.

HOST NOT RESPONDING

Either the link between the TYMCOM and the host is temporarily lost or proper host response to a connect request is not being received. Try again in a few minutes.

HOST SHUT

The Supervisor is not routing new users to the host; current users are not affected. Hang up and log in again in a few minutes.

NO PATH AVAILABLE...DISCONNECTING or LOGON ABORTED...DISCONNECTING

The network is unable to process new log ins at this point; hang up and try again in five minutes.

PLS SEE YOUR REP.

A valid user name or password has not been entered within two minutes after the terminal-identifier entry. Hang up and try again.

PLEASE TRY AGAIN

An attempt has been made to log into a multihost system with an incorrect user name. Log in again with a correct user name.

TRY AGAIN IN 2 MIN

A new Supervisor is taking over the network, or a link has failed; hang up and log in again in a few minutes.

RING NO ANSWER ON PORT X

No connection can be made with the UNIVAC system at this time because the UNIVAC computer is not responding. Try again in a few minutes (the host may be down).

APPENDIX D

SYSTEM 2000 DIAGNOSTIC MESSAGES

SYSTEM 2000 contains a large set of user diagnostics. The diagnostics are generally of two types -- error and informative messages. They are designed to keep the user apprised of system reaction to his actions. This appendix contains many of the SYSTEM 2000 user diagnostics listed numerically*. If the diagnostic message does not appear sufficiently clear by itself, a descriptive paragraph is added.

If a SYSTEM ERROR CODE ...<xxx> is issued, it is the result of a malfunction in the system and not of the user's command. System errors are coded with numbers that are meaningful to programmers maintaining SYSTEM 2000. All system errors are fatal to the rest of the job and may damage the data base. All occurrences of system errors should be immediately reported to PEDCo technical support personnel.

An example of the printout when an error occurs is shown below. It is based on the FGDIS definition; components C5 and C107 are in different data sets.

```
PRINT C5,PRINT C107 WHERE C201 EQ COAL:
................C
SYNTAX ERROR IN COMMAND
```

The "C" (representing Command File) occurs immediately below the point of error.

---

*Each diagnostic message may or may not be preceded by a hyphen (-) or a string of hypens, or a 3-digit number with hypens. Diagnostic messages which begin with a variable, indicated here by the symbols <xxx>, are listed alphabetically at the beginning of this listing.

<MM/DD/YY> <HH/MM/SS> BEGIN SYSTEM 2000 RELEASE <n.nn>

This information message is printed at the start of each SYSTEM 2000 job.

<MM/DD/YY> <HH/MM/SS> END SYSTEM 2000

Informative message printed at the end of a SYSTEM 2000 job that terminates normally.

SYSTEM ERROR ... CODE <xxx>
SYSTEM ERROR ... CODE ERR <xx>

A system error message is the result of a malfunction in the system and not of the user's command. System errors are coded with numbers that are meaningful to programmers maintaining SYSTEM 2000. All system errors are fatal to the rest of the job and may damage the data base. All occurrences of system errors should be immediately reported to PEDCo technical support personnel, with pertinent information saved, such as listings, card decks, and the damaged data base.

SYSTEM RELEASE NUMBER <www>
DATA BASE NAME IS <xxx>
DEFINITION NUMBER <yyy>
DATA BASE CYCLE <zzz>

These four lines constitute the heading for the display when a full DESCRIBE command is issued.

-100-SYNTAX ERROR-

is a non-fatal, non-destructive syntax error. The error message may be followed by one or more additional messages that describe the syntax error in greater detail. Any command not acceptable to the processor in use produces this message.

-204-PARENT DATA RECORD IS MISSING-

is a non-fatal, non-destructive error in the structure of the input data. The data record, indicated by the cursor, does not have a complete line of ancestor data records up to level 0. All of the SRs that are the ancestors of the data record must precede the data record in logical order in the input data.

-205-ITEM DOES NOT BELONG IN CURRENT RECORD-

is a non-fatal, non-destructive error in the input data. The cursor identifies the item as not being in the schema record last given.

-214-DISJOINT CONDITIONS ENCOUNTERED-

is a *non-fatal*, *non-destructive* error. A where-clause can only refer to items from related records unless a has-clause is specified.

-216-TOO MANY CONDITIONS OR SUBEXPRESSIONS-

is a *non-fatal*, *non-destructive* error. In the where-clause, a conditional expression may contain a maximum of seven parts. Each part may be a condition or an expression, and each of these expressions may in turn contain a maximum of seven conditions. No further nesting is allowed.

-217-INSUFFICIENT CONDITIONS OR SUBEXPRESSIONS-

is a *non-fatal*, *non-destructive* error in a where-clause. An integer number was specified to denote the number of conditions that must be satisfied in order to meet the criterion for qualification.

-219-COMMAND TOO LONG-

is a *non-fatal*, *non-destructive* error. This error is not a syntax error. The command was too complex to be interpreted and executed, i.e., there were more than 500 if-conditions. The command must be broken up into several less complex commands.

-227-ITEM VALUED TWICE IN ONE RECORD-

is a non-fatal, *non-destructive* error. Within one data record, the value pointed out by the cursor is the second value for one item. One of the component numbers may be incorrect, a terminator may be missing from the Data File, or a record component number may be missing.

-230-ALL OPERATIONS MUST ACT ON SAME RECORD-

is a *non-fatal*, *non-destructive* error. Action-clause must refer to a record and/or items in that record. The action-clause specifies two different schema record numbers or contains items from two different schema records.

-302-NO PRIOR VALID COMMAND-

is a *warning* that the rejected DITTO did not follow an acceptable command. A DITTO requests that the action-clause of the prior update or retrieval command be reexecuted.

-309-TOO MANY VALUED COLUMNS SPECIFIED-

is a non-fatal, non-destructive error in the retrieval-clause of a LIST command. The clause referred to more than the maximum of 59 items.

-310-SPECIFIED PAGE WIDTH OUT OF RANGE-

is a non-fatal, non-destructive error in the description of the page width for a LIST command. The minimum width is four characters. The maximum width is 131 characters for batch output devices and 71 characters for interactive devices. A page should not be wider than the maximum number of characters for the output device used.

-311-FIRST LIMIT GREATER THAN SECOND-

is a batch fatal, non-destructive error in the specification of the LIMIT <min>, <max>... command. The <min> value must be less than or equal to the <max> value except when <max> is infinite (zero).

-312-FIRST COMPONENT OCCURS AFTER SECOND-

is a non-fatal, non-destructive error in a DESCRIBE <Cm> THROUGH <Cn> command. The component <Cm> must occur earlier in the definition than component <Cn>. <Cm> is displayed before <Cn> in the DESCRIBE output.

-314-ORDERING KEY TRUNCATED AT LEAST ONCE-

is a warning that the command contained an ordering-clause specifying a list of sort items whose values exceeded 364 characters in length. SYSTEM 2000 used the first 364 characters from the specified components to sort the retrieval data records for processing. Any sort characters from values beyond the 364th character were ignored.

-315-TOO MANY ROWS SPECIFIED IN HEADINGS-

is a non-fatal, non-destructive error in the rows designation of a LIST command. This error occurs when more than three S-specifications are given in the TITLE or when SYSTEM 2000 is unable to fit one or more of the column headings into three rows. Two possibilities exist for correcting an error in default layouts. If the TITLE option sets the page width, then the page width could be increased up to 131 characters for batch output devices and 71 characters for interactive devices. Or, the size of the headings could be reduced.

-316-TOO MANY SPECIFICATIONS IN RETRIEVAL-CLAUSE-

is a non-fatal, non-destructive error in the retrieval-clause for a PRINT, TALLY, or LIST command. The clause may have referred to functions, system functions, and/or arithmetic expressions that contain too many operands or operators. Try dividing the command into several smaller commands, perhaps using the SAME capability.

-317-ITEM MUST BE NUMERIC DATA TYPE-

is a non-fatal, non-destructive error in a function, system function, or arithmetic expression that requires a numeric or DATE item type. A NAME or TEXT item type may never be used with SUM, AVG, SIGMA, or in any arithmetic expression.

-319-INVALID USE OF RECORD LABEL-

is a non-fatal, non-destructive error. A schema record label was given where the command required an item label. In a where-clause, schema records can appear only before HAS, HAVE, or HAVING. Further, the only system function operator that can operate on an SR is COUNT. Also, an SR cannot be used with TALLY or LIST.

-320-INVALID LINE SPACING REQUESTED IN S-OPTION-

is a non-fatal, non-destructive error in the specification of the number of blank lines to be included in the printed output for a LIST command. The command contained one or more S(<h>) or S(<h>, <v>) specifications. The values for <h> and <v> cannot be negative or zero. The total number of blank lines represented by the sum of all the h's and v's for all of the S-specifications is so large that a complete output record cannot be printed on a single page of LIST output. This is true only if page length was specified with the F-specification. In this case, perhaps the page length can be increased to a maximum of 60 lines. If the page length is not specified, then all of the output is displayed on a single page of unlimited length.

-322-COMPONENTS MUST BE DESCENDANTS OF BY-PHRASE RECORD-

is a non-fatal, non-destructive error in a by-phrase. The proper form of a by-clause is BY <SR>, <component> [,<component>]... where the records for all components are descendant records of the specified schema record. The system function with a by-phrase must involve records that are descendants of the by-phrase record.

-324-ACTION-CLAUSE COMPONENTS MUST BE IN TARGET RECORD PATH-

is a non-fatal, non-destructive error in a command that computes the value for one item based on another. Either the item on the right of the equals sign is unrelated to the item on the left, or the item on the right was a descendant of the item on the left.

-325-DATA TYPE IN EXPRESSION NOT COMPATIBLE WITH TARGET DATA TYPE-

is a non-fatal, non-destructive error in a command that computes an item value based on a user-supplied value or a value represented by another item. The item or value on one side of the equals sign is DATE or numeric item type and the other side has a CHARACTER or TEXT item type.

-326-ACTION-CLAUSE COMPONENTS MUST BE IN ONE PATH-

is a non-fatal, non-destructive error. An action-clause (including any ordering-clause) refers to components in disjoint schema records. When a retrieval command has a where-clause, the following action-clause components must lie along a single path: each component referenced directly, each by-phrase record, and each ordering-clause component. A retrieval-clause can contain disjoint schema records only if the command has no where-clause and no ordering-clause.

-327-FUNCTION COMPONENTS MUST BE IN ONE PATH-

is a non-fatal, non-destructive error in the components of a function, arithmetic expression, or system function. Two or more items are not in the same path. All items in a function, arithmetic expression, or system function must belong to schema records that lie along a single path.

-329-ITEM LABEL REQUIRED-

is a non-fatal, non-destructive error. A schema record label was used at a place where the syntax requires an item label.

-337-DISJOINT CONDITIONS ENCOUNTERED-

is a non-fatal, non-destructive error. The where-clause referred to unrelated schema records that will produce no qualified records. A has-clause can, perhaps, be used to alleviate this problem.

-339-WARNING - ORDERING-CLAUSE COMPONENTS BELOW RETRIEVAL COMPONENTS-

is a warning that a PRINT or LIST command may produce an unexpected volume of output. The ordering-clause contained components at a level beneath the level of the retrieval-clause. This may cause duplicate output.

-342-<n>SELECTED RECORD(S)-

is an informative message. If <n> is zero, no data records were selected. If <n> is positive, then <n> selected data records were candidates for updating.

-344-TYPE OF WHERE-CLAUSE DIFFERS FROM LAST USE-

is a non-fatal, non-destructive error. When using the WHERE operator with DITTO, the previous request must have had a where-clause.

-345-WHERE-CLAUSE REQUIRED WITH ORDERING-

is a non-fatal, non-destructive error. Ordering takes place on selected data records produced because of the qualification criteria of a where-clause.

-350-TOO MANY LINES SPECIFIED IN HEADING-

is a non-fatal, non-destructive error in specifying a column heading in a LIST command. A heading may not use more than three lines. Therefore, no heading may contain more than two plus signs.

-351-COLUMN WIDTH EXCEEDS PAGE WIDTH-

is a non-fatal, non-destructive error in the specification of the number of columns of output for a single item in a LIST command. The number of columns was wider than the output page. The user may alter the page width or the item's column width.

-352-TITLE AND/OR FOOTING SPECIFICATION MUST APPEAR BEFORE COLUMN HEADINGS-

is a non-fatal, non-destructive error in the title specification for a LIST command. The D-specification (heading) or F-specification (footing) was out of order. The only optional specification that may intervene between TITLE and a D- or F-specification is a page width description; for example, LIST/TITLE (<width> D<n><text>... .

-353-REPETITION OF TITLE OR FOOTING NOT ALLOWED-

is a non-fatal, non-destructive error. The TITLE description contained two title specifications, D(n),...,D(m), or two footing specifications, F(n),...,F(m). Only one of each can be given in a LIST command.

-354-'F' OR 'D' SPECIFICATION IS OUT OF VALID RANGE-

is a non-fatal, non-destructive error in the title option in a LIST command. The integer for a D- or F-specification was less than one or greater than the specified page width or the default page width which is 131 characters for batch output devices and 71 characters for interactive devices.

-355-RECORD LABEL MUST PRECEDE 'HAS'-

is a non-fatal, non-destructive error. A schema record name or C-number is required immediately to the left of the HAS operator.

-365-TOO MANY OPERANDS IN WHERE-CLAUSE-

is a non-fatal, non-destructive error. The where-clause contained more than 80 operands. Operands are components, values, or position indicators (n in AT <n>) appearing with an operator in a where-clause condition. Each component, value, or position indicator in each condition counts as one operand. For example, <item> EXISTS AT <n> contains two operands: item and <n>. The command could be divided into smaller commands with 58 or fewer operators and 80 or fewer operands, perhaps by using WHERE SAME, WHERE SAME AND, or WHERE SAME OR.

-366-TOO MANY OPERATORS IN WHERE-CLAUSE-

is a non-fatal, non-destructive error. The where-clause contained more than 58 operators. In counting operators, a single parenthesis counts as one operator, as do EQ, NE, LT, LE, GT, GE, EXIST, EXISTS, EXISTING, FAIL, FAILS, FAILING, SPAN, SPANS, SPANNING, HAS, AT, NOT, AND, and OR. Commas do not count as operators. The command could be broken up into smaller commands with 58 or fewer operators, perhaps by using WHERE SAME, WHERE SAME AND, or WHERE SAME OR.

-367-NO PRIOR VALID WHERE-CLAUSE-

is a non-fatal, non-destructive error in the positioning of a command that used the SAME operator. Any of the following could have occurred.

°The command with the SAME operator is not preceded by any command with a where-clause.
°The previous where-clause contained an error.

-368-TOO MANY OPERANDS FOR OPERATOR-

is a non-fatal, non-destructive error in a where-clause condition. A value is specified in a condition with a unary operator (FAILS or EXISTS) or a range of values is given in a condition with a binary operator GE, GT, LE, or LT.

-369-UNBALANCED PARENTHESIS-

is a non-fatal, non-destructive error in the use of parentheses in a where-clause. The number of left parentheses does not equal the number of right parentheses.

-379-<n> EXPRESSION RESULTS WERE NULL, UNDEFINED OR OUT OF RANGE-

is a non-fatal, non-destructive error in an arithmetic or system function expression. Computing the expression produced an unacceptable result. For example, division by zero is not allowed.

-384-SYSTEM FUNCTION LEVEL ABOVE TARGET LEVEL, RESULTS MAY BE INCONSISTENT-

is a warning that a PRINT or LIST command may have produced incorrect values for a system function. The target record for the PRINT or LIST command was below the lowest level component in the system function. If logical order and physical order are not identical, a data record may be treated in the system function as if it occurs more than once. An ordering-clause that refers to the target component of the system function and a REPEAT SUPPRESS in the command will correct the situation. Also, REPEAT SUPPRESS and a freshly loaded (no updates) data base produces correct results.

-385-COLUMN HEADING SPECIFIED AFTER CONSECUTIVE S-OPTIONS-

is a non-fatal, non-destructive error. The error occurs when column headings are given after multiple, consecutive S-specifications. S-specifications may appear consecutively at the right end of the TITLE option, or each S-specification may alternate with the corresponding column heading. Consecutive S-specifications should be used only to provide default headings. Otherwise, each S-specification must immediately follow one or more column headings.

-386-SECOND VALUE MUST BE GREATER THAN FIRST-

is a non-fatal, non-destructive error in a where-clause condition containing a ternary operator (SPANS, EQ, NE) followed by two values. The first value was greater than the second value.

-387-ACTION-CLAUSE COMPONENTS MUST BE IN WHERE-CLAUSE PATH-

is a non-fatal, non-destructive error. The action-clause component(s) were disjoint from the where-clause components. Use a by-clause or a has-clause, or omit the where-clause.

-388-UNABLE TO FOLD WITHIN MULTI-LINE COLUMN HEADING-

is a non-fatal, non-destructive error. The error occurs when the first column heading line for a row is equal to or less than the page width, but the second or third is greater than the page width. The default page width is 131 characters for a batch output device and 71 characters for an interactive device.

-502-DATA BASE DOES NOT EXIST-

is a non-fatal, non-destructive error. SYSTEM 2000 is unable to find the requested data base.

-506-CLOSED...<data base><cycle><date><time>-

is an informative message that appears on the Message File whenever a data base is closed. The user is provided the cycle, date, and time information for the data base.

-507-INVALID PASSWORD-

is a batch fatal, non-destructive error. The password is not among the valid passwords for the requested data base. The password specified in the USER command is not acceptable for this DBN IS command.

-508-PASSWORD MUST BE 1 TO 6 CHARACTERS LONG-

is a non-fatal, non-destructive error. Passwords must be one to six alphanumeric characters. Also, the password may be a single special character. If the password is a string of letters or numbers, then it cannot contain special characters or internal blanks.

-510-PASSWORD NOT FOUND-

is a non-fatal, non-destructive error. The password is not in the list of valid passwords for the data base.

-556-OPENED...<data base><definition number><cycle number><date> <time>-

is an informative message indicating that the data base is located on disk and is connected to SYSTEM 2000. The job may access the data base, and SYSTEM 2000 is now in ACCESS. The data base was last updated at time hh:mm:ss on the indicated date (printed under date format control).

-807-MISSING COMPONENT LABEL-

is a non-fatal, non-destructive syntax error. The command lacked a component reference. SYSTEM 2000 expected a component label at a syntactic location where it was missing. The syntax cursor indicates the location of the missing component label.

-808-UNRECOGNIZED COMPONENT LABEL-

is a non-fatal, non-destructive syntax error. SYSTEM 2000 parsed a syntactic unit that should have been a component label. However, the syntactic unit is not a valid component. Either the component does not exist, is not the proper type of component to fulfill its syntactic role, or the units in the command were improperly arranged so that SYSTEM 2000 misinterpreted a syntactic unit as a component. If the valid component identifier appears in an input value stream, it should be a component number rather than a label, i.e., nn rather than Cnn.

-809-SYNTAX ERROR IN COMPONENT NUMBER-

is a non-fatal, non-destructive syntax error. The input value stream contains a component number that is not a positive integer. It may have contained a special character, an alphabetic character (value instead of component number), or an internal blank. SYSTEM 2000 accepts only positive integers as component numbers.

-810-WARNING-DATA BASE DAMAGED. NO UPDATES PERMITTED-

indicates that the damage flag has been set for the data base. This message

- is a warning if this job has just opened the data base. The data base was damaged by a previous job.

- is a warning printed when the data base is closed.

Any time the user discovers his data base is damaged, he should notify PEDCo technical support personnel for corrective action.

-815-COMMAND INVALID, NO DATA BASE OPENED-

is a non-fatal, non-destructive error. The command did not refer to a data base that is connected to SYSTEM 2000.

-820-NON-NEGATIVE INTEGER REQUIRED-

is a non-fatal, non-destructive error. The command contained a negative number or a special character instead of a positive integer.

-864-COMMAND NOT AVAILABLE IN SHARED MODE-

is a batch fatal, non-destructive message in the use of a shared data base. The command required nonshared access to the data base.

APPENDIX E

NTIS APPLICATION FORM

TO APPLY FOR ACCESS TO THE U. S. ENVIRONMENTAL PROTECTION AGENCY (EPA) - NATIONAL COMPUTER CENTER ONLINE DATA BASES, PLEASE COMPLETE THE FOLLOWING ITEMS:

- ONLINE LICENSE AGREEMENT (2 SIGNED ORIGINALS)
- ONLINE BILLING AGREEMENT (1 SIGNED ORIGINAL)

COMPLETED PACKET MUST BE RETUNED TO:

U. S. DEPARTMENT OF COMMERCE
NATIONAL TECHNICAL INFORMATION SERVICE
OFFICE OF DATA BASE SERVICES
5285 PORT ROYAL ROAD
SPRINGFIELD, VA 22161

ONLINE LICENSE AGREEMENT

between

____
(Participating Organization)

and

National Technical Information Service (NTIS)

1. Purpose

The purpose of this Agreement is to provide online access to the U. S. Environmental Protection Agency's (EPA) Flue Gas Desulfurization Information System (FGDIS) data base or software. The system is processed and maintained at the EPA-National Computer Center (NCC) in Research Triangle Park, North Carolina.

2. Availability

This Agreement grants access to the FGDIS data base or software. Other data bases and software systems processed at the NCC are not included as part of this Agreement. Assistance to resolve operating problems and difficulties will be available from the NCC during normal business hours (8:00 a.m. to 5:00 p.m. ET).

3. Reproduction

The Participating Organization will not copy or otherwise reproduce, have reproduced, or willfully allow employees or other parties to copy or otherwise reproduce any portion of the data base or software to a secondary file at the NCC or to a secondary system without advance written approval by NTIS.

4. Payment Terms

The Participating Organization agrees to pay charges assessed by NTIS for online service rendered by the NCC. The charges will be established on the basis of the price schedule as specified in the Online Billing Agreement attached hereto and hereby incorporated within this Agreement.

ONLINE LICENSE AGREEMENT

between

____
(Participating Organization)

and

National Technical Information Service (NTIS)

1. Purpose

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ONLINE BILLING AGREEMENT

FOR EPA & NTIS USE ONLY

DATA BASE/MODEL: ____________
HARDWARE: ____________
ACCT NO: ____________
USER ID: ____________
UID: ____________
BEGIN BILL DATE: ____________

PLEASE RETURN COMPLETED FORM TO:

National Technical
Information Service
Office of Data Base Services
5285 Port Royal Road
Springfield, VA 22161

See reverse side for instructions and charges for online usage.

We elect to pay for dial-up online access to the NCC in the manner specified below (please check one) and indicate account number if appropriate.

[ ] #1 - REGULAR DEPOSIT ACCOUNT   [ ] #2 - DIRECT PAYMENT

Acct # ____________

BILLING ADDRESS (NO PERSONAL NAMES):	PERSON REQUESTING SERVICE:
____________ SECTION, DIVISION, ETC. (40 CHARACTERS/SPACES)	____________ PERSONAL NAME & TITLE
____________ UNIVERSITY, COMPANY, FEDERAL AGENCY, ETC. (25 CHARACTERS/SPACES)	____________ UNIVERSITY, COMPANY, FEDERAL AGENCY ETC.
____________ STREET (40 CHARACTERS/SPACES)	____________ STREET
____________ CITY STATE ZIP (26 CHARACTERS/SPACES)	____________ CITY STATE ZIP
	____________ AREA CODE/TELEPHONE

____
SIGNATURE

____
NAME (TYPE OR PRINT)

FY 1983 Charges on the NCC-UNIVAC Computer *

CATEGORY	FY83 RATE
SRU Hour	$195.00
Tape Rental	$3.50/tape/month
Foreign Tape (B Tape) Storage	$2.00/first day $1.00/day 2-14 $2.00/day over 14
Fixed Mass Storage	$0.05/track/week
Semi-Fixed Disk**	$4800/$8450 pack per month ($0.036/track per week)
Removable Disk**	$150/pack/month
Connect Time	$6.00/connect hour
Plotter	$45.00/plotter hour
Micrographics	Actual cost + 10%
Keypunch	Actual cost + 10%
Special Delivery	Actual cost + 10%
Tape Dearchive	$10/trip
File Dearchive	$13/trip
Tape Purchase	$20/tape
Block Time	$1500/hour

* EPA will add a 15% surcharge which will be reflected in the monthly billing reports, but not in the accounting information on trailer pages. NTIS will include a 15% service charge which will be reflected on the monthly invoice to cover administrative and accounting overhead costs.

** User must back up his own pack(s) or contract with Production Control to have this function performed.

APPENDIX F

FGDIS DUMP PROGRAM

USING THE FGDIS DUMP PROGRAM

BY J. R. SCHOETTELKOTTE
JULY, 1982

THIS FILE CONTAINS THE PROCEDURES FOR GENERATING DATA DUMPS FROM THE PUBLIC VERSION OF THE FGD INFORMATION SYSTEM (FGDIS). DUMPS CAN BE PERFORMED IN DEMAND OR BATCH MODE. OUTPUT CAN BE PUT TO STANDARD FORMS AT NCC OR ST. CLAIR (CINCINNATI) OR TO THE LASER PRINTER.

DEMAND MODE

AFTER LOGGING ON ONE MUST EXECUTE THE FOLLOWING COMMANDS FOR ALL RUNS:

```
@ASG,A FGD.
@ASG,A 11.
@USE 11,11.
@XQT FGD.SELECT
```

THE PROGRAM 'FGD.SELECT' WILL PROMPT FOR THE DATA REQUIRED TO RUN THE DUMP PROGRAM.

TO RUN THE DUMP PROGRAM TO STANDARD FORMS, THE FOLLOWING SHOULD BE EXECUTED:

```
@ADD FGD.DUMPSTD
```

THE OUTPUT FILE 'FGDDS.' CAN BE PRINTED AT NCC'S CENTRAL SITE PRINTER BY EXECUTING

```
@SYM,U FGDDS.,,PR1
```

THE STANDARD FORMS FILE CAN ALSO BE PRINTED AT ST. CLAIR (CINCINNATI). FIRST, ADD THE STATEMENT

```
@MSG,N PDP11 LOC=9990.NAME=FGDDS.
```

AT THE BEGINNING OF THE FILE USING THE EDITOR THEN, EXECUTE

```
@SYM,U FGDDS.,,S08PR1
```

TO RUN THE DUMP PROGRAM TO THE LASER PRINTER, THE FOLLOWING SHOULD BE EXECUTED:

```
@ADD FGD.DUMPLASR
```

THE OUTPUT FILE 'FGDDL.' MUST BE COPIED TO A TAPE AND TRANSFERRED OVER TO THE IBM LASER PRINT STATION. EXECUTE THE FOLLOWING TO ACCOMPLISH THIS:

```
@ASG,AV/W FGDPRT.
@COPY,F FGDDL.,FGDPRT.
@REWIND FGDPRT.
@FREE FGDPRT.
```

AFTER COMPLETION, CALL DATA PROCESSING SUPPORT (919-541-2385) TO NOTIFY THEM OF THE RUN. SUPPLY THE FOLLOWING INFORMATION:

- TAPE REEL NUMBER (6 DIGIT NUMBER APPEARING AFTER 'MOUNTR' ON THE FIN PAGE).
- FORM NUMBER 1250 (8 1/2 X 11)
- 15 CHARACTERS PER INCH
- 8 LINES PER INCH

NOTE, THE FILE 'FGDRL.' HAS SPECIAL FORMS PROCESSING INSTRUCTIONS WHICH PREVENT ITS PRINTING AT OTHER DESTINATIONS.

BATCH MODE

PRIOR TO RUNNING THE BATCH MODE DUMP THE USER MUST LOG-ON IN DEMAND MODE AND LOAD FILE 11. EXECUTE THE FOLLOWING FOR ALL RUNS.

```
@ASG,A FGD.
@ASG,A 11.
@XQT FGD.SELECT
```

THE PROGRAM 'FGD.SELECT' WILL PROMPT FOR THE DATA REQUIRED TO RUN THE DUMP PROGRAM.

IN ADDITION, BEFORE STARTING THE BATCH RUN, ONE MUST EDIT THE FIRST TWO LINES OF THE FILE ELEMENT 'FGD.DUMPBATCHS' (FOR STANDARD FORMS) OR 'FGD.DUMPBATCHL' (FOR LASER PRINT) TO SUPPLY THE PROPER ACCOUNTING INFORMATION. AN EXAMPLE FIRST LINE IS

```
@RUN 80ABC/70,ACCOUNT #/ABC,FGD/FGDIP,10,,D1900
```

WHERE

80ABC = RUN ID
70 = CORE SPACE (A MINIUM OF 67 IS REQUIRED)
ACCOUNT # = ACCOUNT NUMBER
ABC = USER ID
FGD = PROJECT ID
FGDIP = ADP UID
10 = MAXIMUM SUP TIME (10 MINUTES)
D1900 = DELAYS EXECUTION UNTIL 1900 HOURS (7:00 PM) - OPTIONAL

THE SECOND LINE CONTAINS THE '@PASSWD' COMMAND FOR THE USER PASSWORD. AFTER THE PROPER ACCOUNTING INFORMATION HAS BEEN ENTERED EXECUTE

```
@START FGD.DUMPBATCHS
```

FOR STANDARD FORM OUTPUT OR

```
@START FGD.DUMPBATCHL
```

FOR LASER OUTPUT.

THE BATCH JOB STORES THE OUTPUT IN THE FILE 'FGDDS.' OR 'FGDDL.'. AFTER THE JOB HAS RUN, THIS WILL BE THE NEXT DAY IF DELAYED EXECUTION IS USED, FOLLOW THE INSTRUCTIONS ABOVE UNDER DEMAND MODE TO OUTPUT THE REPORT AT THE PROPER DESTINATION.

APPENDIX G

NCC COST OF SERVICES

COST OF SERVICES

The cost of services at the National Computer Center was designed as a non-profit, chargeback system. The user is only billed according to his use of the resources. The system was designed to be fair, simple, predictable, and repeatable.

Chargeback Algorithm

Dollars charged to computer users are determined by the resources used and the level of service requested. Resources are divided into computer run components and computer-related components. Section 2.5.2 describes the computer-related service charges. The chargeback algorithm as presented here is for the SPERRY 1100/82.

Components

Each of the individual pieces of Sperry hardware (and associated overhead) have been placed into one of several categories or "component sets." Initially, there are five different sets, three of which are recovered through the billing algorithm. These sets are described below:

a. CPU. This component set includes the processors and any equipment that directly supports that hardware (such as special electrical equipment). The cost recovery for this component set is via CPU SUP's and will be levied as a runtime charge in the billing algorithm.

b. Memory. All memory is included in this set. The cost recovery for this component set involves the use of memory during CPU and I/O SUP accumulation and will be levied as a runtime charge in the billing algorithm.

c. I/O. This set includes all the mainframe equipment required to support I/O subsystems. This includes I/O units and switches used to reconfigure hardware. The cost recovery for this component set is via I/O SUP's and is levied as a runtime charge.

d. Communications. This set includes all the hardware and associated overhead needed to support demand run communications. The cost recovery for this component set is a runtime charge and involves the "demand connect time" charge. It appears as a separate cost element on the FIN page.

e. I/O Subsystems. This set includes all the disk, tape, and drum subsystems. The cost of this equipment is recovered through miscellaneous charges and appears on the monthly billing statement.

Each component set is considered to be a "cost center." If, for example, the CPU component set costs the Data Center $200,000 per month to support, that component set will be expected to recover that amount of money per month (averaged across a year's processing profile).

System Resource Units (SRU's)

The cost components are combined into one measure known as an SRU. The following formula applies:

$$\#\text{SRU's} = [\text{CPU SUP's} * (A/D) + \text{Memory Use} * (B/D) + \text{IO SUP's} * (C/D)] * P$$

Where:
A = CPU SUP Hourly Rate ($291.60)
B = Memory User Hourly Rate ($1.57)
C = I/O SUP Hourly Rate ($257.38)
D = SRU Hourly Rate ($195.00)
P = Priority Factor

All the above rates became effective on October 1, 1982.

The current values of the priority factor **as of October 1, 1982 are:**

Demand - 2.5
Batch - Deferred - 0.75
Routine - 1.00
Preferred - 2.00
Urgent - 6.00

Weekend rates for all runs submitted after 0800 (Eastern Time Zone) on Saturday will be billed at 50 percent of run costs. Since this weekend rate is applied after the charge is accrued, FIN pages of weekend jobs do not reflect the additional savings.

The memory charges are broken down into separate costs for using memory during CPU usage or doing I/O. It is important to remember that when looking at the time accumulation, memory use represents time per core block (512 words). If the program used five core blocks and accumulated 10 minutes of combined CPU and I/O time, the total memory use would be 50 minutes.

FIN Page Description

Run costs are displayed at the end of each Batch or Demand run in the FIN information as follows:

```
RUNID:  00ZZZZ              ACCT:  88888TEST           PROJECT:  SAMPLE

COMPONENT:  SUPS                    SRUS                     COST

CPU:        00:05:21.367        00:06:00.369         $       019.52
I/O:        00:08:08.517        00:08:03.507         $       026.19

MEMORY USE:

CPU:        07:13:50.791        00:02:37.107         $       008.51
I/O:        11:04:11.539        00:04:00.553         $       013.03

SRU TOTAL:                      00:20:41.538         $       067.25

CONNECT:  00:23:26.000                               $       002.34

IMAGES READ:    380        PAGES:      30

START:      10:30:58  NOV 17, 1982     FIN:      10:54:24   NOV 17, 1982
```

Connect Time and Connect Cost are only displayed for Demand runs. The Total Cost for a Demand run is the summation of the SRU Total Cost and the Connect Cost.

Charging for Computer-Related Services

Charges for Computer-Related Services are computed and billed to the user on a monthly basis. The following is a list of the components and the charges as of October 1, 1982:

Component	Charge	
Tape Rental	$ 3.50	per tape per month
Disk Rental	150.00	per 8433 pack per month
Fixed Mass Storage	0.05	per track per week
Semi-Fixed Mass Storage	4800.00	per 8450 pack per month
Micrographics (Refer to NCC graphics Manual for more details.)	$2.50 + 10% service fee	per original fiche
	$0.25 + 10% service fee	per copy
B-Tape Storage	2.00	for first day
	1.00	per day from 2-14 days
	2.00	per day after 14th day
Tape Purchase	20.00	per reel
Block Time	1500.00	per clock hour
File Dearchive	13.00	per file
Tape Dearchive	10.00	per tape per trip
Keypunching (Refer to Section 3.3.6 for more details.)		per card + 10% service fee
	0.145	12 hour turnaround
	0.118	24 hour turnaround
	0.110	3 day turnaround
	0.102	7 day turnaround
	0.095	14 day turnaround
Special Services		By service category
Special Delivery		Actual cost plus 10% service fee
Demand Connect Time	**$6.00**	**per hour**
Plotter Usage	**$45.00**	**per hour**

Automatic Run Card Generation

Question and Answer Mode Configuration	
Existing User	5.00
New User	0.00
Automatic Mode Configuration	25.00
Removal of Question and Answer Mode	5.00
Removal of Automatic Mode	25.00
Update of Automatic Mode	25.00

Automatic Execution Mode

Enter Mode Configuration	25.00
Change Mode Configuration	25.00
Removal of Automatic Execution Mode	25.00

(Note that a maximum charge of $25.00 per user request is in effect. Therefore, if a combination of any of the above is requested, the account will only be charged $25.00.)

Several items which have no charge are Temporary Mass Storage, Tape Mounts, Unit Record I/O, and Archive Tape Storage.

Cost of Production Control Services and Programming and Analysis Services

Each request for Production Control and/or Programming and Analysis services will be given a cost estimate on an individual task or request basis. It is the intent of the Data Center to collect Program Funds ("green money") for all Production Control and Programming and Analysis services. Program Funds are those funds transferred to the Data Center as a result of processing an EPA form 1900-8, Procurement Request/Requisition.

It is the intention of the Data Center to maintain a relatively constant staffing level in the Production Control and Programming and Analysis sections. If the demand for services exceeds the availability of resources, the Data Center will choose priorities and schedule tasks consistent with that goal. No guarantee is given that the services will be available when they are requested.

Refund Policies and Procedures

Some guidelines, listed below, were developed to address the question of crediting a user's account for runs that fail for reasons other than programmer error. Refunds may be requested through User Support (see Appendix A for address and phone number) for such mishaps as software and hardware errors, operator mishandling, software malfunctions, or mischarges. A refund for a run already billed in the previous month means that the dollar amount charged for that run is subtracted from the total dollars charged to an account in the next billing run.

a. Refunds will be considered for all or part of demand runs but the error or failure must be well-documented. The unique Run-ID, date and approximate time of the error or failure, charges involved if available, and account number of the run must be reported. The request must be in writing and should be accompanied by a printout, if possible.

b. User can request refunds for batch runs by submitting the printout and any other pertinent information to User Support within 12 days after the termination date. Nonlocal users may telephone in charge adjustment requests and supply the following information: actual Run-ID, account number, project code, date and time of run initiation, total SRU's, and the reason for the refund request.

c. Refunds for runs with lost or bad printouts will only be allowed if the following criteria are met.

    1. The cost of the run is less than $100 or the number of printed pages is less than 100. A run over $100 or 100 pages should have been BRKPT'ed to a catalogued file and then SYM'ed with a U option to guarantee good printing.

    2. Run-ID contains the proper bin number.

    3. Run-ID was unique within a 24-hour time period.

d. If a run is less than $100 or 100 pages and was routed to a remote terminal, no refund can be allowed unless there is a problem with the terminal which is documented by User Support.

e. No refund is allowed for runs if FORTRAN-formatted files are SYM'ed to the central site.

f. No refund will be granted for runs where the printout appears to have been lost in the mail.

g. Refunds will be allowed only for runs totaling more than $1. An exception would be for several jobs which attempted the same procedure and failed for the same reason. These jobs individually may be less than $1 but collectively more than $1.

h. In runs whose total SUP's exceed two hours, refunds will be granted for only two hours or that portion of the job that needs to be rerun. Time in excess of that amount must be billed to the user. This guideline does not apply when a run cannot make use of checkpoint/restart during the run. If checkpoint/restart is used and fails to work properly on the restart, both the original run and the restart attempt are eligible for refund. All S2K programs are exempted from using checkpoint/restart.

i. If an error occurs while performing I/O with a B-tape, no refund can be granted for that run.

j. Refunds are granted for read parity errors which cause a job to terminate unsuccessfully.

k. Refunds will be granted for write parity errors when an error is discovered during the first attempt to read that tape. Both runs are considered for refund.

l. Refunds are granted for incorrectly formatted tape labels.

m. Users will be charged for reruns of printouts over 100 pages which are not page numbered.

n. Software-caused errors will only be considered if failure occurred in refundable software. (See Section 11.6.)

o. The user will be refunded only for that part of a run which it is necessary to rerun.

p. The user will be authorized to rerun only at the priority of the initial run.

q. Refunds will not be granted for any of the following:

   1. Errors caused by documented bugs or failure to follow publicized or recommended procedures.

   2. Errors in user programs or runstreams.

   3. Unauthorized runs on account numbers.

   4. Runs which reconstruct a lost or destroyed file not backed up by the user. The loading of files destroyed or lost by the system will be charged to NCC at routine priority (unless the file is private and must be charged to the user). The automatic roll-in of a rolled-out file is charged to NCC.

r. NCC will refund the cost of reloading a removable disk which was damaged by the system at a routine priority.

s. In those instances when a refund is denied and the user feels he has a valid case, the user can appeal, in writing, to the NCC User Services Technical Manager. His decision, however, is final.

APPENDIX H

PROBLEM/SOLUTION ACCESS CODES

All FGD systems that are or have operated in the United States and Japan (coal-fired boilers) are characterized in FGDIS on a monthly basis by the four dependability factors (availability, operability, reliability, and utilization) as well as by removal efficiency (particle and SO_2) and other numeric parameters (boiler hours, capacity factor, etc.) where available. These monthly figures are supported by literal fields in the data base. (The literal fields consist of verbal comments that suggest reasons for the good or bad FGD system performance for that period.) Each of these sentences has an associated start date and end date in a data field that signifies the period to which the comment pertains and a module/system data field identifying a particular module or the entire system as the subject of the comment. These data fields provide some elementary access paths to the explanatory comments supporting the numeric parameters. In addition to these fields, there are three additional data fields that provide a more powerful access to these problem/solution/ comment entries. These data fields are titled as follows: Equipment Code, Problem Class Code, and Problem Type Code.

Equipment/Problem Class/Problem Type Code Descriptions

The problem/solution access codes add a powerful dimension to the literal data fields in FGDIS. By using these codes, the complete history of an individual component for a particular FGD system can be mapped or a complete list of comments related to a particular type of problem can be assembled for a given class of FGD system, a particular component, and/or for a given time period. The codes may also be used directly, for example, to assemble tallys of instances of certain problems.

Equipment Codes--

All major boiler and FGD equipment items are coded. These are shown in Table H-1. This table shows the particular item names with associated codes grouped by general component/equipment.

Problem Class Codes--

Table H-2 provides a list of the problem classifications and associated codes contained in FGDIS. All comments entered in the literal data fields are labeled as chemical-related, design-related, etc., to give some clue as to the cause of a particular problem. As with the other codes, these may be

TABLE H-1 . EQUIPMENT CODES

Name	Code
Power generation	
Steam generator	SG
Turbine generator	TG
Cooling tower	CT
Air preheater	AP
Auxiliary equipment	AE
Particle control	
Mechanical collector	MC
Fabric filter	FF
ESP	EP
Particle scrubber	SC
FGD system	
Quencher	QN
Presaturator	PS
Absorber	AB
Mist eliminator	ME
Reheater	RH
Fan	FN
Reagent preparation equipment	
Ball mill	BM
Slaker	SL
Classifier	CL
Reagent handling equipment	RE
Solids concentration/dewatering	
Hydrocyclone	HC
Centrifuge	CN
Vacuum filter	VF
Thickener	TH
Sludge handling	SH
Other	
Stack	SK
Gas damper	GD
Ductwork	DW
Expansion joint	EJ
Agitator	AG
Tank	TA
Pump	PU
Process control	PC
Instrumentation	IN
Valves	VL
Spray nozzles	SN
Piping	PI
Not specified	NS
Byproduct recovery	BR
Sludge treatment	ST
Pug mill	PM

TABLE H-2. PROBLEM CLASS CODES

Class	Code
Chemical	CH
Design	DE
Environmental (weather-related, etc.)	EN
Installation	IN
Mechanical	ME
Other	OT
Not specified	NS

TABLE H-3. PROBLEM TYPE CODES

Problem type	Code
Corrosion	CO
Erosion	ER
Component failure	FA
Flow distribution	FD
Component inefficiency	IN
Materials failure	MF
Oversized component	OC
Plugging	PL
Scaling	SC
Undersized component	UC
Vibration	VI
Not specified	NS

accessed directly, for example, to total the number of units that have experienced design-related problems in general or for particular components.

Problem Type Codes--

Table H-3 provides a list of the problem types and associated codes contained in FGDIS. As with the previously mentioned codes each literal data field entry is labeled as corrosion, plugging, vibration, etc.

Examples of how these codes are interpreted are provided in Table H-4.

TABLE H-4 . EXAMPLES

Presaturator/chemical-related/corrosion	PS/CH/CO
Fan/installation-related/vibration	FN/IN/VI
Mist eliminator/chemical-related/plugging	ME/CH/PL

APPENDIX I

GLOSSARY OF FGD SYSTEMS/ FGDIS-RELATED DEFINITIONS

Absolute humidity - The weight (or mass) of water vapor in a gas water-vapor mixture per unit volume of space occupied.

Absorber - General term for those gas/liquid contacting devices designed primarily for the removal of SO_x pollutants.

Absorption - The process by which gas molecules are transferred to a liquid phase during scrubbing.

Additive reagent - That particular chemical compound or element which is added to the FGD process as an additional reagent to promote improved process operation (see process additives).

Adiabatic saturation temperature - When unsaturated gas is brought into contact, under adibatic conditions (no heat losses to the surrounding environment), with an aqueous solution at a lower constant temperature, the gas is cooled and humidified. When the temperature reached by the saturated gas is identical to the temperature of the aqueous solution, the gas has reached the adiabatic saturation temperature.

Adsorption - The process by which gas molecules are removed from a gas stream by means of adhesion to the surface of a solid.

Agitator/mixer - A slowly rotating rake, or set of blades or paddles fastened to a shaft and motor used in tanks and thickeners to promote completion of chemical reaction, maintain underflow solids in a fluid state, maintain a homogenous slurry, or to rake underflow solids to a center discharge sump.

Air-to-cloth ratio - (Also referred to as gas-to-cloth ratio.) The volumetric rate of capacity of a fabric filter; the volume of air (gas) in cubic feet per minute, per square foot of filter media (fabric).

Alkaline fly ash scrubbing - An FGD process that uses the alkaline constituents of fly ash collected from the burning of western coals as the primary absorbent.

Alkalinity - Represents the amount of carbonates, bicarbonates, hydroxides, or phosphates contained in the water, scrubber liquor, or sludge.

Acoustic coupler - A device used between the modem of a computer terminal and a standard telephone line to permit transmission of digital data in either direction without making direct connections.

Alphanumeric - The set of all alphabetic and numeric characters, along with related symbols.

Ambient - Pertaining to the pressure, air quality, temperature, etc. conditions of the surrounding environment of a plant or scrubbing system.

Annual outage - A scheduled period of time (generally four to six weeks) set aside by the utility once per year to shut down the boiler and/or FGD system for inspection and maintenance.

ASCII - Binary code or byte pattern which represents characters used in communicating between terminals and computers; vocabulary consists of 128 characters with 7 bits per character.

Atomizer - A device used to disperse a liquid (water/slurry) into a gas stream by reducing the liquid into a fine spray.

Availability index - Ratio of hours an FGD system was "accessible" for operation to the hours in the time period (regardless of actual operation time), expressed as a percentage. NOTE: This parameter tends to overestimate the viability of the FGD system because it does not penalize for election not to operate the system when it could have been operated. Boiler downtime may tend to increase the magnitude of the parameter because FGD failures generally cannot occur during such periods.

Available hours - The amount of time in hours an FGD system was "accessible" for operation.

Axial flow fan - A mechanical air mover that consists of propeller-like blades rotating in a plane perpendicular to the gas stream about a shaft resting in a plane parallel to the gas stream.

Ball mill - A rotating drum loaded with steel balls that is used to crush and slurry materials such as limestone to a particle size suitable for efficient chemical reactivity.

Base load - A generating station which is normally operated to take all or part of the base load of a system and which, consequently, operates at a constant output.

Batch - A processing mode whereby a program is submitted to the computer, and the result is delivered back. No interactive communication between program and user is possible.

Baud - A variable unit of data transmission speed usually equal to one bit per second.

Bench scale level - An FGD process of very small scale (laboratory or "bench" scale in size).

Bit - The physical representation of a bit by an electrical pulse, a magnetized spot, or a hole whose presence or absence indicates data (1 binary digit - a zero or one).

Blanking plate - The simplest of dampers consisting of a steel plate which is bolted into place to close off and isolate ducts and/or scrubbers.

Blinding (fabric filter) - The loading or accumulation of filter cake on a fabric filter "bag" to the point where capacity rate is diminished.

Blinding (reagent) - A phenomena where chemical reaction of a reagent particle in a scrubbing slurry is primarily limited to the surface of that particle so that less than 100 percent of the reagent molecules within the particle are exposed to the gas molecules that are to be collected.

Blowdown - The purge of part or all of a liquid circuit to remove cumulating soluble contaminants from the circuit that cannot be otherwise removed (e.g., by precipitation).

Bottom ash - Heavy solid particles of noncombustible ash that fall to the bottom of the boiler.

Butterfly damper - A damper consisting of a simple plate that opens or closes by turning the plate parallel or perpendicular to the gas flow.

Bypass reheat - A system which boosts the temperature of the saturated flue gas leaving a scrubbing system above dew point by ducting a slip stream of particle-cleaned flue gas from the ESP exit duct past the scrubbing system to the scrubber outlet duct or directly to the stack preventing stack damage from acid rainout.

Byproduct (recoverable byproduct) - Gypsum, sulfur, sulfuric acid, liquid SO_2, sodium sulfate or other saleable materials produced by various regenerable type scrubbers are considered recoverable byproducts.

Byproduct nature - The nature (e.g., elemental sulfur, sulfuric acid) and disposition (e.g., stockpile on site, marketed) of the end product by systems that generate a saleable product.

Byte - A group of adjacent binary digits often shorter than a word that a computer processes as a single character (1 byte equals 8 bits).

Calcite (calcitic lime or limestone) - A crystallized mineral consisting of calcium carbonate ($CaCO_3$).

Capacity factor - The ratio of the average load on a boiler for the period of time considered to the capacity rating of the boiler (actual kWh produced/theoretical kWh produced x 100).

Carryover - Entrained solids, slurry droplets, and/or mist that leaves with the flue gas stream exiting a particular stage of a scrubber or absorber.

Centrifugal fan - An air mover that consists of a drum of blades or slat type vanes aligned parallel to the entering gas stream that rotates rapidly about an axis also parallel to the entering gas stream casting the gas outward into the housing and through an exiting duct connected tangentially to the housing.

Centrifugal separation - The separation of phases in a composite fluid stream by applying a circular motion to the stream and forcing the higher density component to the outside wall of the device, where it is collected.

Centrifuge - A drum and worm gear type machine that separates solids from the entering slurry stream by centrifugal force as the drum and gear rotate at slightly different speeds.

Character - Letters, numbers, or symbols; each character is represented by 1 byte or 8 bits.

Characters/sec. - Speed at which letters, numbers, or symbols are printed by printer.

Chloride - A compound of chlorine with another element or radical.

Citrate process - A scrubber that absorbs SO_2 in a sodium citrate solution loaded with H_2S to precipitate sulfur.

Clarifier - A continuous settling basin used in wastewater treatment application producing a clear overflow and a concentrated sludge from the bottom.

Closed water loop - The water loop of a scrubbing system is closed when fresh makeup water added exactly equals the evaporative water loss leaving via the stack and the water chemically or physically bonded to the sludge product.

Cocurrent flow - A scrubbing process in which the absorbent liquor or slurry enters the scrubbing chamber from the same direction as the gas stream so that SO_2 collection occurs as the gas and liquid pass simultaneously through the chamber.

Cold side - An ESP located downstream of the boiler air preheater.

Combination tower - A scrubber type that consists of a combination of two or more scrubber types within the same tower such as a level of sprays followed by a level of packing material (spray/packed type combination tower).

Commercial level - Proven full-scale FGD processes which are installed to bring a boiler or boilers into compliance with SO_2 emission regulations (generally on a scale of 100 MW or greater, but may have capacities as low as 60 MW).

Commercial service date (boiler) - Date when the boiler turbines begin contributing power to the power grid.

Commercial service date (FGD system) - Date when the FGD system successfully completes compliance testing and the utility is satisfied that the system meets supplier contractual guarantees.

Common name/design - The trade name or descriptive title for a typical specific type (e.g., turbulent contact absorber (TCA) type scrubber/absorber, fin tube type in-line reheater or 317L type stainless steel).

Company name - Name of a utility company, corporation, or cooperative, etc. as it appears in Electrical World - Directory of Electrical Utilities, McGraw-Hill - Current Edition as space permits in the data base field size. Company name pertains to the operating utility for a given boiler and not necessarily the primary owner.

Condensation - The process of changing a vapor into liquid by the extraction of heat.

Condenser - A piece of equipment used to convert a vapor state to liquid state by compression or extraction of heat.

Configuration (horizontal/vertical mist eliminator) - A horizontal configuration is one in which the mist eliminator lays across the vertical duct or absorber tower with the wet gas rising up through the mist eliminator. A vertical configuration is one in which the mist eliminator is fastened vertically in a horizontal duct run downstream of the absorber tower.

Continuous analyzer - Gas or liquid monitoring devices which automatically take readings or measurements on a continual basis (e.g., SO_x, NO_x, O_2, etc. continuous stack monitors).

Cooling tower blowdown - The wastewater characterized by high concentrations of soluble salts periodically purged from the boiler cooling tower and sometimes used as makeup for the FGD system.

Corrosion - The deterioration of a metallic material by electrochemical attack.

Countercurrent flow - A scrubbing process in which the absorbent liquor or slurry enters the scrubbing chamber from the opposite direction of the gas stream so that SO_2 collection occurs as the gas and liquid collide in the scrubbing chamber.

Crosscurrent flow - A scrubbing process in which the absorbent liquor or slurry enters the scrubbing chamber perpendicular to the gas stream flow so that SO_2 collection occurs as the gas and liquid paths intersect.

Cycling load - A generating station which is operated continuously but fluctuates its load throughout a given day based on electrical demand (system grid requirements).

Cyclone - A piece of air pollution hardware used for particle removal that uses centrifugal separation to effect particle collection.

Cyclone boiler - Boilers utilizing horizontal cylinder furnaces in which combustion air and crushed coal are cyclonically (whirling motion) fed for combustion.

Cyclonic separator - A type of mist eliminator that separates and removes entrained solids, water droplets, and mist from a gas stream by centrifugal separation.

Damper - A plate or set of plates or louvers in a duct used to stop or regulate gas flow.

Demonstration level - A full-scale FGD system introducting a design and/or process previously unproven at full-scale capacities installed less for SO_2 compliance than to prove the commercial acceptability of the design and/or process.

Density meter - Electronic device used to measure fixed density (mass per unit volume).

Dependability - The generic term for the FGD System Performance Factors; availability, reliability and utilzation; as defined in this glossary.

Development level - The stage to which a process has evolved with respect to full scale commercial acceptability (e.g., full scale, demonstration, prototype, etc.).

Dewpoint - The temperature at which vapor contained in saturated flue gas begins to condense.

Direct combustion reheat - A flue gas reheat system that boosts the temperature of the saturated gas from a scrubber above dewpoint by injection into the gas stream of the hot combustion products generated by oil or gas reheater burners.

Disposal - (Also referred to as sludge disposal.) Removal of and discarding of non-saleable waste from an FGD system in the form of ponding, landfilling, mine filling, etc.

Dolomite (dolomitic lime or limestone) - A crystallized mineral consisting of calcium magnesium carbonate ($CaMg(CO_3)_2$).

Dual alkali (also double alkali) - An FGD process in which SO_2 is removed from the flue gas in two stages by two reagent loops. The first loop absorbs SO_2 in a clean soluble (usually sodium-based) scrubbing liquor. The SO_2 is precipitated as calcium sulfite and calcium sulfate as the spent liquor cycles through the second loop and is regenerated.

End product:

Saleable--The SO_2 removed from the flue gas is recovered in a usable or marketable form (e.g., sulfur, sulfuric acid, gypsum, sodium sulfate, ammonium sulfate, etc.).

Throwaway--The SO_2 removed from the flue gas is not recovered in a usable or marketable form and the resulting sulfur-bearing waste products must be disposed of in an environmentally acceptable fashion.

Energy consumption - The percentage of gross unit electrical generating capacity consumed by the FGD system, as defined by the following equation:

[Net MW w/o FGD - Net MW W/FGD]/[gross unit rating]

Entrainment - The suspension of solids, liquid droplets or mist in a gas stream.

Equivalent scrubbed capacity (ESC) - The effective scrubbed flue gas in equivalent MW based on the percent of flue gas scrubbed by the FGD system.

Erosion - The action or process of wearing away of a material by physical means (friction).

ESP (Electrostatic precipitator) - An air pollution device used to remove particles from an exhaust stream by initially charging them with electrodes and then collecting them on oppositely charged plates.

Excess air (percent) - The percentage of air supplied for combustion in excess of that theoretically required for complete oxidation.

Exit gas recirculation reheat - A flue gas reheater in which a portion of the heated stack gas is diverted, heated further (to approximately 400°F) by an external heat exchanger and injected to the wet flue gas stream exiting the scrubbing system.

Expansion joint - A small section of ductwork or piping that is designed to passively expand or contract as required by the flexing of more rigid duct runs, piping or pieces of equipment as such components are exposed to varying external and internal temperatures.

Fabric filter (baghouse) - A particle collector that consists of a chamber within which a series of column-like bags are fastened by the bag openings to a panel so that dust particles are collected on the outside bag surface or inside surface (depending upon the fabric filter design) as raw flue gas is forced or drawn through the chamber.

Fan - A piece of equipment designed to move air by creating a high or low pressure through mechanical means.

Fatigue - A tendency of a material to break or weaken under repeated stress.

FD (forced draft) - A fan or blower used to produce motion in an enclosed stream of gases by creating a positive pressure in the stream, effectively pushing it through the system.

Feedback control - An automatic control system in which information about the controlled variable (SO_2, temperature, pH, etc.) is 'fed back' after scrubbing has taken place as the basis for control of the process variable (reagent feed, steam, etc.).

Feedforward control - An automatic control system which measures an 'upstream' process variable (gas flow rate, temperature, slurry flow rate, and/or pH, etc.) and compensates immediately without waiting for a change in the controlled variable (SO_2, temperature, pH, etc.) 'downstream' to indicate a change has occurred.

FGD battery limits - An imaginary boundary that encompasses all equipment, ponds, special liners, etc. that would not otherwise be installed if an FGD system was not required.

FGD dependability indexes - The four parameters availability, operability, reliability, and utilization used to characterize the operation of an FGD system during a given period.

FGD status -

Category 1 - Operational--The FGD system is in service removing SO_2.

Category 2 - Under construction--Ground has been broken for installation of the FGD system, but the FGD system has not become operational.

Category 3 - Contract awarded--A contract has been signed for purchase of the FGD system but ground has not yet been broken for actual installation.

Category 4 - Letter of intent signed--A letter of intent has been signed, but a legal contract for purchase has not been awarded.

Category 5 - Requesting/evaluating bids--Bid requests have been released but no letter of intent or contract has been issued.

Category 6 - Considering only FGD for SO_2 compliance--An FGD system is proposed as a means to meet an SO_2 regulation.

Category 7 - Considering FGD and alternatives--An FGD system as well as alternative compliance strategies are being considered to meet an SO_2 regulation.

Category 8 - Terminated FGD system--An FGD system has been operated in the past but has been shut down permanently or for an extended indefinite period of time.

Category 11 - Cancelled Units - the utility reported that it planned to install a coal-fired boiler equipped with an FGD system. However, the plans were later dropped because of revised power demand projections or other reasons, and the unit was therefore cancelled.

Fixation - Increasing the chemical stability of FGD waste through chemical means such as addition of alkali, alkaline fly ash, etc. usually in conjunction with dewatering and blending of inert solids; or through the use of commercial processes (e.g., POZ-O-TEC, Calcilox, etc.) to produce a chemically stable solid.

Flooding - The situation in a countercurrent gas-liquid operation when the gas velocity is high enough to impede the flow of liquid through the tower. Excessive entrainment usually is a consequence of flooding.

Flyash - Fine solid particles of noncombustible ash carried out of the boiler by the exiting flue gas.

Forced outage - The scrubbing system is taken out or forced out of service to make necessary repairs or modifications to the FGD system regardless of boiler availability such that the scrubbing system is unavailable for service.

Forced oxidation - A process in which sulfite-containing compounds are further oxidized to sulfate compounds by aeration with air or pure oxygen to promote dewatering, ease of handling, and/or stability in the waste product.

Free space - Voids within the packing material in a packed tower-type scrubber.

Freeboard distance - The distance between the top or end of the scrubber section and the beginning of the mist eliminator section where entrained particles can coalesce and return to the scrubber solution by gravity before encountering the mist eliminator.

Fuel firing rate - Boiler fuel firing rate in terms of tons per hour at maximum continuous load.

Full duplex - Allowing telecommunication in opposite directions simultaneously between terminals and computers.

Full scale - A conventional FGD process usually accommodating flue gas from a 100 MW or greater sized steam generator.

Gas contacting device - Grids, balls, marbles, trays, rods, or other obstacles in the gas path within a scrubber/absorber intended to effect intimate mixing and promote the gas-liquid transfer of SO_2 to the scrubbing liquor or slurry.

Gas-to-cloth ratio - (Also referred to as air-to-cloth ratio.) The volumetric rate of capacity of a fabric filter; the volume of air (gas) in cubic feet per minute, per square foot of filter media (fabric).

Gas/liquid distribution (in scrubbers) - The presence of random mixing of flue gas with scrubber liquor throughout a wet scrubbing device without the occurrence of static pockets or streams of uncontacted gas and liquor.

Generic process type - The general method of SO_2 absorption of an FGD system (e.g., lime slurry, sodium carbonate scrubbing, lime/spray drying).

Generic type - The general name or descriptive title of a group of scrubbers, mist eliminators, materials, etc. (e.g., packed tower type absorber, impingement type mist eliminator, stainless steel type construction material). The first and primary of three classification categories used to characterize each of the major equipment or equipment areas in FGD systems.

Guillotine damper - A damper whose operation is characterized by a vertical or horizontal sliding gate or plate resembling a guillotine as it is moved into and out of the gas path.

Half duplex - One-way telecommunication between terminal and computer.

Header - A pipe or duct run from which gas or liquid is tapped off by spray pipes or secondary ducts along the way.

Heat exchanger - Device used to transfer sensible and/or latent heat from one stream of material to another to raise or lower the temperature of one of the materials.

Heat rate - A measure of generating station thermal efficiency, generally expressed in Btu per net kilowatt-hour. It is computed by dividing the total Btu content of fuel burned for electric generation by the resulting net kilowatt-hour generation.

High grade alloy - A special mixture of metals chosen for corrosion resistance characterized by relatively high concentrations of chromium and molybdenum (a minimum of 20 percent and 25 percent respectively for iron base and 15.5 percent and 16 percent respectively for nickel base) to optimize corrosion resistance to H_2SO_4 and HCl.

Hot side - An ESP located immediately upstream of the boiler air preheater.

Hydration water loss (sludge) - Moisture contained in the sludge that is not physically or chemically bonded to the sludge molecules leaving the FGD system with the waste stream.

Hydrocyclone - A wet centrifugal separator used to separate suspended solids in a slurry from the liquor.

ID (induced draft) - A fan used to move an enclosed stream of gases by creating a negative relative pressure in the stream to effectively draw the gas through the system.

I/O - Input/output. The communication of information to and from a computer or peripheral device.

Impingement - A generic mist eliminator or scrubber/absorber type that operates such that mist or particles/SO_2 are removed by collection on surfaces placed in the gas stream.

Indirect hot air - A flue gas reheat system in which reheat is achieved by heating ambient air with an external heat exchanger using steam at temperatures of 350° to 450°F.

Initial startup date (FGD system) - Date when flue gas first passes through any component of the FGD system (or is scheduled to do so).

In-line reheater - A heat exchanger installed in the wet flue gas duct downstream of the mist eliminator usually consisting of hot water or steam coils used to boost the wet flue gas temperature above dewpoint.

Inorganic protective lining - Bricks, ceramics, concrete, and other materials usually characterized by inelasticity, high resistance to heat, and minimal permeability to liquids, particularly acid, which are used to line internals of scrubbing system and stacks.

Input device - Any machine that allows you to enter commands or information into the computer's main (RAM) memory. An input device could be a typewriter keyboard, an organ keyboard, a tape drive, a disk drive, a microphone, a light pen, a digitizer, or electronic sensors.

Interstitial water loss (sludge) - Water tapped in the FGD waste that is physically and/or chemically bound by the molecular structure of components in the sludge.

Knock-out tray - A wash tray type pre-mist eliminator using valve or bubble cap type mechanisms to capture the bulk of the entrained solids, droplets, and mist carrying over from the scrubber/absorber of an FGD system.

Landfill - A method of waste disposal in which the dried FGD byproduct wastes are dumped and packed, or buried between layers of earth near ground level or below ground level.

L/G ratio (liquid-to-gas ratio) - The ratio of the total liquid exposed to the gas stream in an FGD system (in gallons) to the inlet gas flow rate (in increments of 1000 acf).

Liner - A metal, or organic or inorganic type material applied to a shell of an FGD system component which is intended to protect the shell from abrasion, heat, and/or corrosion.

Load factor - The ratio of the average load in kilowatts supplied during a designated period to the peak or maximum load in kilowatts occurring in that period.

Louver damper - A damper consisting of several blades each pivoted about its center and linked together for simultaneous operation.

Makeup water - Water added to an FGD system to maintain a certain slurry solids level by making up for water losses to evaporation and exiting waste streams.

Mechanical collector - A piece of equipment used to remove particles from a flue gas stream by mechanical means such as centrifugal force without the benefit of electrostatics or agglomeration brought about by the injection of liquids.

Mechanical dewatering equipment - Devices used to decrease the moisture level of FGD waste to a degree that the material can be handled more easily and disposed of as a stable solid suitable for landfill (e.g., vacuum filter, centrifuge, hydrocyclone, etc.).

Mesh pad - A type of mist eliminator consisting of a knitted wire mesh that captures entrained solids, droplets, and mist by impingement.

Mine fill - A waste disposal method in which a mine or an area of a mine is used as a disposal site for FGD waste.

Mist - Dispersion of relatively large liquid particles in a gas stream: carryover from a gas-liquid contact operation.

Mist eliminator - A piece or section of pollution hardware used to remove a dispersion of liquid particles from a gas stream.

> Primary collector--A mist eliminator that removes entrained solids, water droplets, and mist not collected by the precollector.
>
> Precollector--A mist eliminator that directly follows the scrubber/absorber and is intended to remove the bulk of the entrained solids, water droplets, and mist from the flue gas stream.

Mist eliminator passes/stage - The number of direction changes the gas stream must make before it exits the mist eliminator stage.

Mist eliminator stages - The number of separate individual mist eliminators (e.g., 2-stage mist eliminator - bulk separator followed by an impingement collector).

Mist eliminator vane angle - The angle measured between the intersection or vertex of any two interconnecting vanes.

Mixer - (Also referred to as agitator.) A set of blades or paddles fastened to a shaft and motor used in tanks to promote completion of chemical reaction, maintain underflow solids in a fluid state, or maintain a homogenous slurry.

Modem - A combination modulator and demodulator at each end of a telephone line to convert binary digital information to audio tone signals suitable for transmission over the line, and vice versa. Also known as dataset. Derived from modulator-demodulator.

MW - Megawatt - 1000 kilowatts - standard parameter for characterizing utility boiler turbine capacities.

NA - Not available - early status - information not known at this time.

N/A - Not applicable.

New (as opposed to retrofit for FGD systems) - FGD unit and boiler were designed at the same time or space for addition of an FGD unit was reserved when the boiler was constructed.

NO_x - A symbol meaning oxides of nitrogen (e.g., NO and NO_2).

NR - Not reported - the information is known but for one reason or another has not been reported by the utility.

NSPS - New Source Performance Standards - Environmental regulations that apply to a new installation referring primarily to the Federal NSPS that applies to installations beginning construction on or after August 17, 1971.

Opacity - The degree to which emissions reduce the transmission of light and obscure the view of an object in the background.

Open water loop - The water loop of a scrubbing system is open when the fresh makeup water added exceeds the evaporative water loss leaving via the stack and the water chemically or physically bonded to the sludge product.

Operability index - Hours the FGD system was operated divided by boiler operating hours in a given period, expressed as a percentage. NOTE: This parameter indicates the degree to which the FGD system is actually used, relative to boiler operating time. The parameter is penalized when options are exercised not to use the FGD system in periods when the system is operable. In addition, an undefined value can result when neither the boiler nor the FGD system is operated for a given period (e.g., turbine or boiler outage when FGD system is available).

Operating hours - The amount of time in hours a boiler or FGD system actually "functioned."

Operational status - The FGD system is in service removing SO_2.

Organic protective lining - Resins, polyester, bituminous, epoxy, vinyl ester, rubber, and other lining materials usually characterized by elasticity, low resistance to heat, and minimal permeability to liquids, particularly acid.

Outage - That period of time when the boiler and/or FGD system is shut down for inspection and maintenance. Outages may be either forced or scheduled.

Overflow - (Also referred to as supernatant.) The clear liquor that is drawn from the top of settling tanks (e.g., thickener, clarifier) or settling ponds.

Oxidation - A chemical reaction in which oxygen unites or combines with other elements or compounds in an FGD system (primarily with respect to the sulfite-sulfate reaction).

Packed-bed scrubber - A piece of pollution equipment using small plastic or ceramic pieces, with high surface area-to-volume ratios, for intimate contact between liquid and gas for mass transfer of a pollutant.

Packed tower - A tower (usually cylindrical) used for pollutant removal by a packed scrubber. Untreated gas enters the bottom and travels upward, and liquid enters the top and travels downward.

Particulate - Finely divided solid particles entrained in the gas stream (fly ash, coal fines, dried reaction byproducts, etc.)

PC (pulverized coal) - Solid coal reduced to a fine size (i.e., 70 percent through a 200 mesh screen).

Peak load - A boiler that is normally operated to provide power during maximum load periods.

pH - The hydrogen ion concentration of a water or slurry to denote acidity or alkalinity.

pH meter - Electronic instruments which measure the potential difference between a reference half-cell electrode and an indicator electrode sensitive to hydrogen ions.

Pilot level - FGD systems which introduce design and/or processes that have not been proven at full scale capacities; much like that of a demonstration system but on a much smaller scale (10 MW or less).

Plant name - Unit identification as it appears in Electrical World - Directory of Electrical Utilities, McGraw-Hill - Current Edition - or as indicated by a utility representative for installations in planning stages.

Plume (stack plume) - The visible emission from a flue (stack).

Pozzolanic reaction - The reactive process which takes place when scrubber sludge (calcium-based, calcium regenerated, or double-alkali) is mixed with fly ash and/or lime to form a cement type solid material for disposal purposes.

Preheater - Heat transfer apparatus through which ambient air is passed and heated by higher temperature boiler flue exhaust gases for boiler combustion.

Presaturator - An external vessel or section of incoming flue gas ductwork prior to the main scrubbing vessel where hot flue gas is presaturated.

Pressure drop - The difference in force per unit area between two points in a fluid stream, due to resistive losses in the stream.

Process additives - A chemical compound or element which is added to the process or normally found with the main process reagent in small quantities (e.g., Mg, adipic acid) to promote improved process operation (e.g., scale reduction, increased SO_2 removal efficiency).

Process type - The generic name for a scrubbing process based on the absorbent used except for a few specialized processes which are referred to by patented titles (e.g., lime, limestone, Wellman Lord, Thoroughbred 121, etc.).

Prototype - FGD systems which introduce novel designs or chemical processes (generally on a scale of 10 to 50 MW, but may approach 100-MW capacity).

Pug mill - A mechanical device used for blending ash and/or other dry solid materials with sludge to enhance its handling characteristics for disposal purposes.

Pulverized coal boiler - Boilers whose furnaces are operated on a stream or streams of powder-like pulverized coal that is injected into the furnace as a fluid and burned.

Quencher - The inlet portion of the main scrubbing vessel where hot flue gas is cooled and saturated.

Reactant reagent - The actual chemical substance or compound utilized by an FGD process for pollutant removal (e.g., CaOH, $CaCO_3$, etc.).

Reagent - The substance which contains or produces the desired reactant reagent material utilized by an FGD process for pollutant removal (e.g., lime, limestone).

Reagent preparation equipment - Equipment and/or mechanical devices involved in the handling and preparation of the scrubber reagent (slakers, wet ball mills, pug mills, etc.).

Reagent utilization - (Also referred to as utilization.) That fraction of reagent material (e.g., lime, limestone) fed to the FGD system which is consumed (utilized) and chemically converted into product material (e.g., $CaSO_3$, $CaSO_4$, etc.).

Redistributor - A device used to spread out the flow of liquid in a packed scrubber to insure uniform wetting of packing material.

Regulatory class -

A: Standard(s) More Stringent Than NSPS (6/79)--Unit(s) subject to standards more stringent than NSPS as promulgated in June 1979.

B: Federal NSPS (6/79)--Unit(s) subject to Federal New Source Performance Standards (NSPS) promulgated in June 1979.

Regulatory class (continued) -

C: Standard(s) More Stringent Than NSPS (12/71) But Not More Stringent Than NSPS (6/79)--Unit(s) subject to standard(s) as suggested by the title.

D: Federal NSPS (12/71)--Unit(s) subject to Federal New Source Performance Standards (NSPS) promulgated in December 1971.

E: Standard(s) Equal to or Less Stringent Than NSPS (12/71)--Unit(s) subject to standard(s) as suggested by the title.

Reheater - Device used to raise the temperature of the scrubbed gas stream to prevent condensation and corrosion of downstream equipment, avoid visible plume, and/or enhance plume rise and dispersion.

Relative humidity - (Also referred to as relative saturation.) The ratio of the weight (or mass) of water vapor present in a unit volume of gas to the maximum possible weight (or mass) of water vapor in unit volume of the same gas at the same temperature and pressure.

Relative saturation - (Also referred to as relative humidity.) The term "saturation" refers to any gas-vapor combination, while "humidity" refers specifically to an air-water system.

Reliability index - Hours the FGD system was operated divided by the hours the FGD system was called upon to operate expressed as a percentage. NOTE: This parameter has been developed so as not to penalize the FGD system for elected outages, e.g., periods when the FGD system could have been run but was not because of chemical shortages, lack of manpower, short duration boiler operations, etc. The main problem in using this formula is the concise determination of whether or not the system was "called upon to operate" during a given time period. In addition, an undefined value can result when the FGD system is not called upon to operate for a given period (e.g., turbine or boiler outage when FGD system is available).

Removal efficiency:

Particulate matter--The actual percentage of particulate matter removed by the emission control system (mechanical collectors, ESP, or fabric filter and FGD) from the untreated flue gas.

SO_2--The actual percentage of SO_2 removed from the flue gas by the FGD system.

Total unit design removal efficiency--The designed percentage of mass of SO_2 or particulate matter entering the stack to the mass of the material in the flue gas exiting the boiler regardless of the removal efficiency of an individual component or the percentage of the exiting flue gas actually being scrubbed.

Residence time - The amount of time a unit volume of gas or liquid spends in a pollution control device.

Retrofit - The FGD unit will be/was added to an existing boiler not specifically designed to accommodate an FGD system.

Rod deck scrubber - Gas/liquid contacting device used for pollutant removal. Untreated flue gas is contacted countercurrently with scrubber liquor with mixing being aided by decks of cylindrical rods positioned perpendicular to the gas and liquor flows.

Saleable end product - Any material produced from the byproducts or inlet materials of an FGD process, with the original purpose being pollutant removal, which is resaleable (e.g., gypsum, elemental sulfur, sulfuric acid, etc.).

Saturated - The situation when a gas or liquid is filled to capacity with a certain substance. No additional amount of the same substance can be added under the given set conditions.

Saturation temperature - The temperature to which flue gas drops when it is saturated by scrubbing in a wet FGD system.

Scale - Deposits of slurry solids (may be calcium sulfite and/or calcium sulfate) that adhere to the surfaces of scrubber equipment, particularly scrubber internals and mist eliminator surfaces.

Scheduled outage - A planned or "scheduled" period of time set aside periodically for inspection and maintenance of the boiler and/or FGD system.

Scrubber - A device that promotes the removal of pollutant particles and/or gases from exhaust streams of combustion or industrial processes by the injection of an aqueous solution or slurry into the gas stream.

Scrubber/absorber module - General term for the chamber and associated hardware in which SO_2 and/or particulate matter is removed from the flue gas stream.

Scrubber train - A series of physical and/or chemical unit operations for pollutant removal from exhaust streams, carried out in a series of modules.

Settling pond - Sludge dewatering ponds which generally are not preceded by dewatering equipment. Scrubber bleed is normally introduced at one end of the pond and supernatant drawn off at the other end and recycled back for scrubber reuse. Settling ponds may or may not be final disposal areas.

Slagging - Scaling of precipitate or buildup of particulate material on equipment surfaces.

Slaker - Mechanical devices which slake dry lime (calcium oxide) or magnesium oxide into calcium or magnesium hydroxide alkali.

Sludge - The material containing high concentrations of precipitated reaction byproducts and solid matter collected and/or formed by the FGD process (composed primarily of calcium-based reaction byproducts, excess scrubbing reagent, flyash, and scrubber liquor).

Sludge disposal - (Also referred to as disposal.) Removal of and discarding of non-saleable waste from an FGD system in the form of ponding, landfilling, mine filling, etc.

Sludge pond - Sludge dewatering ponds which generally are preceded by either dewatering equipment and/or settling ponds. The sludge pond is usually the final disposal area.

Slurry - A watery mixture of insoluble matter (usually lime or limestone).

SO_2 removal mode - The manner in which the SO_2 from the flue gas is collected, e.g., wet scrubbing, spray drying, dry adsorption.

SO_x - A symbol meaning oxides of sulfur (e.g., SO_2 and SO_3).

Spalling - The deterioration of stone, concrete, or ceramic materials because of chemical or physical action.

Spare capacity index - % - The summation of the individual component capacities (%) minus 100%.

Spare component index - The equipment spare capacity index (%) divided by the individual component capacity (%).

Specific type - A distinct design variation of a basic generic (equipment) type.

Spray dryer - A scrubber consisting of spray tower type chamber in which hot flue gas is contacted with an atomized reagent solution or slurry and SO_2 collection occurs as the moisture contained in the atomized particles evaporates leaving a dry powder-like waste product.

Spray tower - Gas/liquid contacting device used for pollutant removal. Untreated gas is contacted countercurrently, crosscurrently, or cocurrently with scrubber liquor via spray nozzles in a horizontal or vertical chamber.

Stabilization - Physical stabilization is accomplished by reducing the moisture content of the sludge by addition of non-alkaline flyash and/or using a vacuum filter or centrifuge to the point that structural properties are optimized when the material is disposed of in a landfill.

Stabilization pond - Sludge ponds containing stabilized sludge.

Stack annulus - The space formed between the outer perimeter of the stack flue and the inner perimeter of the stack wall proper.

Stack flue - The inner duct or channel in a stack through which the flue gas is conveyed.

Stack gas velocity - The exiting velocity of the flue gas out the top of the stack.

Stacked packings - Ceramic, plastic, or wood materials placed in a packed tower in layers.

Stacking (gypsum stacking) - The means and/or method (process) used for gypsum disposal.

Standard conditions - A set of physical constants for the comparison of different gas volume flow rates (60°F, 1 atmosphere pressure).

Static bed - A type of scrubber packing consisting of a largely immobile bed of glass spheres (marbles) or other immobile material which aids scrubber liquor/flue gas mixing.

Status - (See FGD Status.)

Stoichiometric ratio - A molar ratio of reactants in a chemical process; indicates to what extent lime (or other reagent) is added to the reaction in excess of the theoretical amount required.

Stress corrosion cracking - The cracking of metal caused by the simultaneous presence of tensile stress and a specific corrosive medium.

Structural fill - The use of FGD byproduct waste as fill material for construction purposes (e.g., ash, stabilized and/or fixated sludge).

Superficial gas velocity - The average flue gas velocity through a mist eliminator or other component of an FGD system.

Supernatant - (Also referred to as overflow.) The clear liquor that is drawn from the top of settling tanks (e.g., thickener, clarifier, etc.) or settling ponds.

System supplier - A firm that fabricates and supplies flue gas desulfurization systems.

Temperature, dry-bulb - The temperature of a gas or mixture of gases indicated by an accurate thermometer after correction for radiation.

Temperature, wet-bulb - Wet bulb temperature is a measure of the moisture content of air (gas). It is the temperature indicated by a wet bulb psychometer.

Theoretical kWh production - Period hours x gross unit operating capacity in kilowatts.

Thickener - A continuous settling basin used to increase solids concentration from influent to underflow.

Throwaway end product - Those byproduct materials formed by FGD systems which have no resale value with or without additional processing.

Total controlled capacity (TCC) - The gross rating (MW) of a unit brought into compliance with FGD, regardless of the percent of flue gas treated at the facility.

Total discharge head (TDH) - The reading of a pressure gauge at the discharge flange converted to feet of liquid and corrected to the pump centerline plus the velocity head (in ft) at the point of gauge attachment.

Trade name - Common names and/or "trade" names assigned to special or proprietary equipment designs.

Tray tower - Gas/liquid contacting device used for pollutant removal. Untreated gas enters the base of the tower and passes upward through trays containing openings countercurrent to downward cascading scrubber liquor introduced from above each tray.

Treatment - The specific type of dewatering preparation used on FGD waste material (sludge) to prepare it for final disposal (e.g., fixation, stabilization, vacuum filters, thickeners, etc.).

Turnaround - Common term referring to an annual scheduled outage period.

Turndown ratio - The ratio of maximum gas flow capacity of a scrubber to the minimum it can handle without reducing SO_2 removal or causing unstable operation.

Underflow - Concentrated solids flow from the bottom of a clarifier, scrubber, or thickener.

Unit rating:

Gross-Operational - maximum continuous generating capacity in MW.
Gross-Preoperational - maximum continuous design generating capacity in MW.

Net w/FGD--Gross unit rating less the energy required to operate ancillary station equipment, inclusive of emission control systems.

Net w/o FGD--Gross unit rating less the energy required to operate ancillary station equipment, exclusive of the FGD system.

Utilization - (Also referred to as reagent utilization.) That fraction of reagent material (e.g., lime, limestone, etc.) fed to the FGD system which is consumed (utilized) and chemically converted into product material (e.g., $CaSO_3$, $CaSO_4$).

Utilization index - Hours that the FGD system operated divided by the total hours in the period. NOTE: This parameter is a relative stress factor for the FGD system. It is not a complete measure of FGD system viability because the parameter can be strongly influenced by conditions that are external to the FGD system (e.g., infrequent boiler operation will lower the value of the parameter although the FGD system may be highly dependable in its particular application).

Vacuum filter - A drum and belt type machine that separates solids from slurry by use of vacuum pressure.

Variable pitch fan - Fans equipped with moveable vanes such that the vane angle (pitch) can be altered.

Venturi scrubber - An air pollution device used to accelerate concurrent liquid and gas flows for more turbulent and intimate contact.

Wash direction - Location and/or direction of wash water spray with respect to mist eliminators (e.g., top, bottom, side).

Wash water type - The nature of wash water spray utilized for mist eliminators (e.g., continuous, periodic).

Waste heat recovery reheater - Those reheat systems in which the sensible heat contained by the hot flue gas upstream of the scrubbers, which would otherwise be lost in quench and scrubbing operations, is recovered by an in-line heat exchanger and used downstream to reheat cooled treated flue gas.

Water loop - All aqueous mass flows from inlet (e.g., seal water, quench water, scrubber liquor) to outlet of an FGD system (e.g., evaporation via stack, pond evaporation, sludge disposal).

Water losses - Water leaving the scrubbing system via the stack (evaporation), pond, and/or thickener and also water that is chemically or physically bonded to the disposal sludge product.

WC (water column) - (Also WG or water gauge.) Units of pressure expressed as inches of water.

Wear plate - A replaceable sheet of metal or other material installed at areas where high abrasion and/or impingement conditions exist for scrubber internal protection.

Weeping - The situation in an absorption tower when the gas velocity is too low and does not provide for intimate contact between phases.

Wet stack - Stacks equipped with special liners for handling the continual condensation of moisture contained in the exiting scrubbed flue gas.

Zero discharge - A pollution regulation requiring that no effluent waste stream be discharged back into the environment, with the exception of evaporation via ponds and stacks (e.g., pond runoff or direct piping of spent slurry or sludge into nearby waterways or contributories would be prohibited).

EPA-600/8-85-023
(ierl-RTP-1596)
(20 cc)

Covers 1 & 2	2
i → x	10
1 → 185	185
A-1 → 15	15
B-1 → 5	5
C-1 → 3	3
D-1 → 13	13
E-1 → 6	6
F-1 → 3	3
G-1 → 8	8
H-1 → 5	5
I-1 → 23	23
cover 4	1
	279 pgs